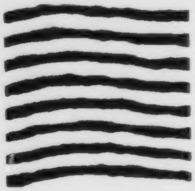
MINERAL REPORT No 37

1988

CANADIAN MINERALS YEARBOOK



REVIEW AND OUTLOOK

Energy, Mines and Resources Canada   Énergie, Mines et Ressources Canada

©Minister of Supply and Services Canada 1989

Available in Canada through

Associated Bookstores
and other booksellers

or by mail from

Canadian Government Publishing Centre
Supply and Services Canada
Ottawa, Canada K1A 0S9

Catalogue No. M38-5/37E
ISBN 0-660-13150-1

90-00652/

Foreword

The year 1988 was notable for its strong prices, especially in the case of base metals, and high volumes of mine shipments for nearly all mineral and metal commodities. EMR estimates that the total value of output for the minerals industry in 1988 increased a further 2% over 1987, from $36.3 billion to $37.1 billion. Metallic minerals, and particularly the nonferrous metals, were once again the star performers, rising by almost 26% in value.

Investment for the future has also shown a positive trend. Based on Statistics Canada data, companies have invested $4.6 billion in Canadian mining in 1987, and 1988 figures, while not yet complete, should be of the same order. Exploration expenditures in Canada peaked at about $1.3 billion in 1987 and could be close to this level in 1988.

This edition of the Canadian Minerals Yearbook reports on the activity of the mineral industry during 1988. The General Review identifies the predominant economic events of 1988 and indicates the major trends in the Canadian economy. It also covers the general developments and overall patterns of the mineral industry during the year. The regional and international scenes are covered in separate reviews while chapters on Labour and Employment and Canadian Mineral Exploration are also included. The 48 commodity chapters - the work of the Mineral and Metal Commodities Branch of the Mineral Policy Sector - feature economic developments, uses, prices, exports and production and consumption figures specific to each commodity. The Outlook section under each commodity review provides a forecast of the industry's future position.

The basic statistics on Canadian production, trade and consumption, unless otherwise stated, were collected by the Information Systems Division, Mineral Policy Sector of Energy, Mines and Resources Canada, and by Statistics Canada. Market quotations were taken mainly from standard marketing reports. Corporate data were obtained directly from company officials through surveys or correspondence, or were extracted from annual reports. Energy, Mines and Resources Canada is grateful to all those who contributed information used in the preparation of this report.

Additional copies of the Yearbook can be purchased from the Canadian Government Publishing Centre. Reprints of individual chapters and Map 900A, Principal Mineral Areas of Canada, may be obtained free of charge from:

Publications Distribution Office
Mineral Policy Sector
Energy, Mines and Resources Canada
580 Booth Street
Ottawa, Ontario
K1A OE4

Previous editions of the Canadian Minerals Yearbook have been deposited in various libraries across Canada.

May 25, 1989

Production Manager: J. Bureau
Coordinator and Editor: G. Cathcart
Graphics and Make-up: T.-C. Young

Typesetting (text and tables):
- S. Brazeau
- K. Angyal
- S. Davidson
- L. Leclerc-Rocheleau
- S. O'Malley

Contents

1. General Review
2. International Review
3. Regional Outlook
4. Labour and Employment
5. Summary of Canadian Ore Reserves
6. Canadian Mine Reserves, Development and Promising Deposits
7. Canadian Mineral Exploration
8. Aluminum
9. Antimony
10. Arsenic*
11. Asbestos
12. Barite and Celestite*
13. Bentonite*
14. Beryllium*
15. Bismuth*
16. Cadmium
17. Calcium*
18. Cement
19. Cesium*
20. Chromium
21. Clays
22. Coal
23. Cobalt*
24. Columbium (Niobium)*
25. Copper
26. Crude Oil and Natural Gas
27. Diatomite*
28. Fluorspar*
29. Gallium and Germanium*
30. Gold
31. Graphite
32. Gypsum and Anhydrite
33. Indium
34. Iron Ore
35. Lead
36. Lime
37. Lithium
38. Magnesium
39. Manganese*
40. Mercury*
41 Mica*
42. Mineral Aggregates
43. Molybdenum*
44. Nepheline Syenite and Feldspar*
45. Nickel
46. Peat
47. Phosphate
48. Platinum Metals
49. Potash
50. Primary Iron and Ferrous Scrap
51. Rare Earths*
52. Rhenium*
53. Salt
54. Selenium and Tellurium*
55. Silica
56. Silicon, Ferrosilicon, Silicon Carbide and Fused Alumina*
57. Silver
58. Sodium Sulphate
59. Stone
60. Sulphur
61. Talc, Soapstone and Pyrophyllite*
62. Tantalum
63. Tin
64. Titanium and Titanium Dioxide
65. Tungsten
66. Uranium
67. Vanadium
68. Zinc
69. Zirconium and Hafnium*
70. Principal Canadian Nonferrous and Precious Metal Mine Production in 1987, with Highlights for 1988
71. Statistical Report

* The review for this commodity was not produced for 1988.

General Review

A.B. SIMINOWSKI

THE CANADIAN ECONOMY IN 1988

The Canadian economy, in its sixth year of expansion since the 1981-82 recession, continued to be very buoyant throughout 1988. Despite the impending gloom that prevailed regarding the outlook for the economy, following the October 1987 stock market crash, the economy surged ahead at a faster rate than in 1987. Real economic growth, measured by the Gross Domestic Product (GDP), is estimated to have increased by about 4.2% over 1987 which, in turn, had recorded an economic growth of 4.0%. In fact, it has been estimated by the Organization for Economic Cooperation and Development (OECD) that economic growth in Canada in 1988 was second among the world's seven leading industrial democracies, with Japan first.

The unemployment rate in 1988 remained at the 7.7% to 7.9% range compared to 8.9% for 1987. This represents the lowest unemployment rate since 1981.

Although consumer spending was weak during the first quarter of 1988, relative to a strong fourth quarter in 1987, it gained about 1.0% in each of the two succeeding quarters, and is estimated to have increased by 3.3% over 1987. The economic performance in 1988 can best be characterized by the strength of business investment, following up on a strong year for investment in 1987.

Overall, new capital investment plans for 1988 (including private and public sector investment) increased by $14.4 billion to $123.0 billion, a 13.3% increase over the 1987 level. The business sector provided the major impetus for a strong economic performance in the country, increasing its planned expenditures by $12.8 billion over 1987. This increase brought the business sector's investment intentions for the year to $74.3 billion, a 20% improvement over the $61.5 billion estimated for 1987. This increase in investment was influenced by the need for more production capacity to meet growing demand in both domestic and export markets. For example, the rate of capacity utilization for goods-producing industries was reported as 86.5% in the second quarter of 1988. Indeed, some industries had been operating at more than 90% of capacity. Corporation pre-tax profits rose by about 15% at an annualized rate for the first half of 1988. This is noteworthy inasmuch as corporate profits had already increased by 24% in 1987. A key factor behind increased profits over the past year was the sharp increase in the prices of industrial materials, including metals.

Residential construction continued to be very strong in 1988 and was more buoyant than had been anticipated, particularly in light of the boom year that the housing industry had enjoyed in 1987. Housing starts were projected to total about 210 000 for the year compared to 246 000 in 1987.

With the economy continuing to show robust growth, there were genuine concerns throughout the year of an over-heated economy and the resultant inflationary pressures. Control of inflation was the key policy concern of the Bank of Canada. Over the course of the year, the bank rate increased from 8.66% to 11.2%. The Consumer Price Index (CPI) increased by about 4.2% in 1988, compared to a slightly higher increase of 4.4% in 1987.

The Canadian dollar exhibited considerable strength during 1988. It was generally up relative to the U.S. dollar, aided by the differential in Canadian-U.S. interest rates, the strength of the Canadian economy, investor confidence in Canada's economic prospects and the Canada-U.S. Free Trade Agreement (implemented on January 1, 1989). In December 1987, the Canadian dollar had traded at an average of about US76.5¢. By late November 1988, it soared to its highest close in almost seven years by reaching US84.32¢.

A.B. Siminowski is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 992-7267.

Merchandise exports increased by 10.2% for the first ten months of 1988 compared to 1987 while imports increased by 12.6%. As a result, the merchandise trade surplus to the end of October totalled $8.6 billion down from $9.9 billion for the corresponding period in 1987. A trade surplus in the order of about $10 billion was projected for the year in total. However, in terms of total international transactions (including exports, imports, services, investment income and transfers), Canada has been recording a deficit in recent years. Canada's current account deficit for the first nine months of 1988 amounted to $5.9 billion compared to $7.2 billion in 1987. For the year in total, a current account deficit in the order of $8.5 billion was projected.

The strength of the Canadian economy relies to a considerable extent on the strength of the U.S. economy. This can be realized by noting that exports of goods and services account for approximately one third of the total output of Canada's economy and that three quarters of total merchandise exports go to the United States. Growth in the U.S. economy (as measured by Gross National Product) in 1988 was estimated to have been in the order of 3.9%, compared to 3.4% in 1987. As in Canada, there were similar concerns regarding the dangers of an overheated economy and rising inflation. The unemployment rate averaged about 5.5% over the year, the lowest rate in some time. In fact, in June the jobless rate had dipped as low as 5.3%, the lowest rate in 14 years. Prime interest rates in the U.S. continued an upward trend since the first quarter of the year. The rate of inflation was held in check at about 4.4%. While exports surged and imports slowed, the U.S. trade deficit (about $140 billion in 1988) as well as the federal budget deficit, continued to be major concerns.

THE MINERAL INDUSTRY IN 1988

Rising base metal prices and the benefit of sustained productivity increases resulted in an earnings boom for Canada's mineral industry in 1988. Indeed, there were indications that earnings for most companies in the base metal mining industry would be the highest in ten years. This follows favourably on the results of the previous year. The price increases during 1988 reflected tighter global supply of minerals as the mine closures and smelter rationalizations of the past few years finally brought production more in line with demand.

Over the past year, financial markets have seen a low U.S. dollar. Since mineral commodities are priced internationally in U.S. dollars, this has had the effect of pushing up prices, reinforcing the impact of tight commodity supplies.

The sustained price boom for many commodities during 1988 was most beneficial to the mining sector. In the current upswing, mining industry profitability has improved markedly. For example, one survey of the major companies in the mining sector indicated that after-tax profits in the third quarter of 1988 rose by 15% from the second quarter. This represented a 136% increase over the corresponding quarter a year ago. For the metal mines industries overall, Statistics Canada reported a net income of $890 million for the first half of 1988 compared to $178 million for the first half of 1987. While improved profitability has been largely attributable to higher metal prices, it has also been assisted by improved productivity. Mining companies had responded to the severe price downturns for their products in the early 1980s by cutting back their work forces, by implementing more efficient mining methods, by adopting new technologies and by closing high cost operations. It has been reported that in some operations productivity was doubled and that productivity improvements of 50%, or more, were quite common.

Investment expenditure intentions for nonfuel mining in 1988 reflected the continued strength and optimism in this sector. The intended expenditure of $2.4 billion for investment in new capital in 1988 was an increase of nearly 28% over the $1.8 billion estimated for 1987. The 1987 level itself had represented an increase of about 14% over 1986. In the mining sector overall (including fuels), intended capital expenditures for 1988 were $8.7 billion up 30% over 1987.

The value of Canadian mineral production, including metallic minerals, nonmetallic minerals, structural materials and fuels, totalled $37.1 billion in 1988 compared with $36.3 billion in 1987.

The metallic minerals sector was the major performer in 1988, with value of output reaching $13.8 billion, an increase of 25.8% over the $11.0 billion recorded in 1987. The value of production of the nonmetallics grew to $2.7 billion, an increase of 12.6% over the previous year. The value of output for structural materials increased by 1.6% to $2.8 billion. While the nonfuel sector of the mineral industry made gains in production value, the fuels sector experienced a decrease of 12.0%, largely as a result of lower oil prices. Production volumes, however, did increase for each of the fuels in 1988. The fuel sector, which includes crude petroleum, natural gas, natural gas by-products and coal accounted for $17.8 billion, or 48.1% of the overall value of mineral output.

The top ten commodities in terms of value of output in 1988 were as follows: petroleum, $9.3 billion; natural gas, $5.0 billion; nickel, $3.3 billion; copper $2.3 billion; gold, $2.2 billion; zinc, $2.1 billion; coal, $1.9 billion; natural gas by-products, $1.6 billion; iron ore, $1.4 billion; and uranium, $1.1 billion.

Alberta's contribution to total mineral output represented the largest share, contributing $14.9 billion or 40.2% of total output. Ontario was second with a value of $7.2 billion or 19.3% of the total. In third through sixth places, respectively, were British Columbia at $4.0 billion, Saskatchewan at $3.0 billion, Quebec at $2.7 billion and Manitoba at $1.7 billion. The remaining provinces and territories accounted for $3.6 billion, roughly 10% of the total.

The employment level for the industry overall increased in 1988 by about 1.5% over the 1987 level, reflecting the sustained strength of Canadian mining throughout the year. Employment in mining (including coal mining) and mineral manufacturing was estimated in 1988 to be 392 000 compared to 386 000 in 1987.

Employment in metal mines, nonmetal mines including coal, and structural materials was estimated to be 77 000 in 1988, an increase of about 2.0% over 1987. Employment in smelting and refining and in the crude steel industries increased by 2.8% to 75 000, while mineral manufacturing employment increased by 1.0% to 240 000.

Flow-through share financing was expected to supply about $900 million for mining exploration in 1988. The success of the program was largely a result of the continuing exploration expenditures associated with the search for gold. On May 3, 1988, the federal government introduced its new exploration incentive program for resource industries, the Canadian Exploration Incentive Program (CEIP), which replaces the Mining Exploration Depletion Allowance (MEDA). CEIP took effect on January 1, 1989 for grass roots exploration in the mining sector. (For oil and gas exploration, CEIP took effect on October 1, 1988.) The program modifies but maintains the popular flow-through share financing mechanism and is designed to improve opportunities for junior firms to maintain an adequate level of exploration financing.

Exports of Canadian minerals continue to make an important contribution to Canada's merchandise trade surplus. Exports of crude and fabricated minerals (excluding fuels) were estimated at $18.5 billion for 1988. Crude minerals accounted for about $5.5 billion, while fabricated minerals made up the remaining $13.0 billion. Exports to the United States accounted for about 55% of the total in 1988, followed by the European Economic Community (including the United Kingdom) at 15% and Japan at 15%. Mineral exports, including fuels, made up nearly one quarter of the value of Canada's domestic exports during 1988.

Imports of crude and fabricated minerals were estimated at $9.4 billion in 1988, up from the $8.4 billion recorded in 1987.

COMMODITY TRENDS

Nickel was the major performer of the year. In 1988, the volume of output increased by 13.1% and the value of production rose by 155.8%. Volumes reached 214 000 t compared to 189 000 t in 1987, while the value of production soared to $3.3 billion from $1.3 billion in the previous year. With a buoyant world economy, high demand (particularly for use in stainless steel) and tight supply, nickel prices reached record levels. Nickel prices had begun to rise significantly during the last quarter of 1987. This momentum was carried through to 1988 and in late March the LME price peaked at US$10.84/lb. Although the price subsequently slipped somewhat from the highs in March and April, it remained well up on the year and averaged US$6.25/lb.

The value of gold output in Canada was $2.2 billion in 1988, up only marginally from the 1987 level, while the quantity of gold produced increased from 116 t in 1987 to 12[illegible] t in 1988. The continuing success of flow-through share funding in raising capital for exploration, combined with an average gold price of US$437/oz. over the year, maintained much of the focus on this commodity. In 1987, gold prices had averaged US$447/oz. Even though the price of gold had been slipping over the year (and even fell below US$400 in September, the first time in 19 months), gold mining continues to be very profitable and gold projects continue to come on stream.

The production of silver rose by 11.1% in 1988 to 1 527 t from 1 375 t in 1987, but the value of output declined by 10.8% to $378 million, down from $424 million in the previous year. Although silver had staged a comeback in 1987 with an average price at close to US$7.00/oz., it was not able to maintain that level in 1988. The price of silver averaged about US$6.50, although it had rallied to the US$7.00 range in mid-year.

Copper output fell by 9.1% in 1988 to 722 000 t down from 794 000 t in 1987. However, the value of production soared by 20.5% to $2.3 billion, reflecting high copper prices throughout the year. On the basis of strong demand and very tight supply, the copper price averaged US118.0¢/lb. (LME Grade A settlement). Toward year end, the price rallied to new highs as a result of supply interruptions.

The volume of lead output fell by 10.6% in 1988 to 334 000 t, down from 373 000 t in 1987. Correspondingly, the value of production fell by 15.5% to $334 million. Lead prices remained firm throughout the year and averaged US29.7¢/lb. on the LME. While the demand for lead is falling, there is continued demand for lead in automotive battery production. Supply and demand are expected to remain broadly balanced.

Zinc output was 1.3 Mt in 1988, an increase of 8.3% over the 1.2 Mt reported in 1987. The value of output increased to almost $2.1 billion, a 40% increase over the $1.5 billion realized in 1987. On the basis of strong demand and tight supply, zinc prices maintained a very strong upward trend throughout the year. For example, in January, the LME HG cash price averaged US39.8¢/lb., while in November it was US85.8¢/lb. The average for the year was US51.1¢/lb., about 40% higher than in 1987.

Canada's output of molybdenum fell to 12 400 t in 1988 from 14 800 t in 1987, while the value of production fell to $108 million from $126 million. The price of molybdenum improved somewhat over its level at the start of the year. The Metals Week dealer price averaged US$3.44/lb. The industry suffers from excess capacity which is ready to be brought on stream whenever there is a clear sign of higher prices.

Canada's iron ore production grew by 2.8% in 1988, increasing from 37.7 Mt in 1987 to 38.7 Mt. The value of production remained essentially unchanged at $1.4 billion. Increased consumption of Canadian iron ore in the European and U.S. export markets reflected an increase in the production of crude steel. In Canada, the steel industry maintained about the same level of production as in 1987.

The volume of asbestos production increased to 705 000 t from 665 000 t in 1987, while the value of production increased to $268 million from $238 million. Exports of asbestos to Asia and South America have been increasing, offsetting export losses to the United States and Western Europe.

Potash production increased to 8.1 Mt in 1988 from 7.7 Mt in 1987. The value of production grew to $1.1 billion, a major increase from $745 million recorded in the previous year.

OUTLOOK

For 1989, as Canada entered the seventh year of its current economic expansion, economic forecasters were in general agreement that the economy would continue to expand, but at a slower rate than had been experienced over the past few years. Projected growth rates for 1989 were in the general range of 2.0% to 2.5%, with an overall projected average of about 2.3%. Since 1983, the economy had been growing at an average rate of about 4.3% a year. The anticipated slowdown reflects the expectation of higher interest rates and a weaker housing industry. It also reflects an uneasiness about the continuing longevity of the current expansion, which began in the first quarter of 1983 and is the second longest on record. (The longest period of continuous growth occurred between 1961 and 1973). While slower economic growth carries with it the risk of a recession, the general consensus is that this would not occur.

The inflation rate is expected to increase to approximately 5.0% in 1989. The unemployment rate is also expected to nudge upward to approximately 8.0% from the 7.8% average in 1988, a slight reversal in the downward trend of the past few years. Most forecasters also expected interest rates to be higher in 1989, at least for the first half of the year. This reflects the Bank of Canada's continuing focus on inflation and the need to keep raising interest rates in order to keep inflationary pressures in check. However, most economists expect interest rates to begin falling about midway through 1989, reflecting the anticipated slowdown in the economy. The value of the Canadian dollar is expected to moderate somewhat from the US83¢ to US84¢ range that it had been trading at during the latter part of 1988.

The personal saving rate (personal savings as a percentage of personal disposable income) has gradually fallen from a high of 18% in the first quarter of 1982, to about 8.5% in 1988. Consumer spending is expected to slow down in 1989. However, it will still be a major factor in Canada's economic growth. Most of the forecasts for consumer spending indicated an increase of 2.0% to 3.0% in 1989, compared to 3.3% in 1988 and 4.7% in 1987.

Housing starts are expected to decline to a range of about 170 000 to 190 000 in 1989, compared to an annual average of about 220 000 over the past three years. This slowdown is anticipated as a result of the projected slowdown in the economy and rising interest rates.

Business investment is expected to continue to be a strong contributor to Canada's economic performance. After double-digit growth in 1988 (with estimates by economists ranging between 14% and 21%), investment in plant and equipment is forecast to increase by approximately 6.0% in 1989.

Slower economic growth is also projected for the United States. The general consensus was that 1989 growth would be in the 2.0% to 2.5% range, compared to about 3.9% in 1988. The impact of this would be reduced growth for Canadian exports in 1989. While the growth in Canadian imports is also expected to moderate, import growth will continue to be relatively strong as a result of the continued strength in business spending on machinery and equipment. With import growth generally expected to exceed export growth, Canada's current account deficit is forecast to widen to about $10 billion, compared to about $9 billion in 1988.

Higher interest rates and lower economic growth will put upward pressure on the federal government's budget deficit. Private sector economists were forecasting that this would result in a budget deficit of about $32 billion to $33 billion for the fiscal year 1989-90.

Mining and other resource-based industries are expected to continue to be a source of strength for the Canadian economy in 1989. Although economists generally are predicting a lower rate of world economic growth in 1989, the Canadian mineral industry seems reasonably well-placed to withstand such a slowdown and to compete successfully in export markets. Having become more cost-efficient as a result of the recession in the early 1980s, the industry has met the challenges of rationalization and restructuring. Increases in labour productivity have been sustained; production costs have been brought down to more competitive levels; and prices for several key metals have moved upwards. Fuelled by tight inventories and sustained economic growth in the world's economies, mineral markets appear to be balanced and tight.

While markets have been very buoyant for many commodities, it appears that very high prices for metals have peaked and that lower price levels should be anticipated over the next year. While it is expected that prices will fall somewhat in 1989, metal markets are expected to continue to be buoyant, with prices remaining at satisfactory levels. Barring a recession, base metal analysts do not see prices falling as rapidly as they have climbed over the past year. The strength of capital investment in the world's economies should maintain a good level of demand for base metals.

A bilateral free trade agreement with the United States, which came into place on January 1, 1989 is expected to enhance export opportunities for Canada's metals and minerals. Organizations such as the Mining Association of Canada are supportive of the free trade agreement with the United States. While current duties on metals are not particularly high, a more important benefit of the free trade agreement is seen as the creation of a dispute settlement mechanism to resolve differences arising from protectionist measures such as the application of antidumping or countervailing duties.

There are challenges still to be met, however. For example: international competition for the mineral industry remains fierce; declining intensity-of-use for some of the traditional metals moderates the growth in demand; shifts towards substitute materials, such as plastics, are reinforced if metal prices remain at very high levels; high costs of adhering to environmental restrictions and regulations add to the costs of base metal production. In addition, declining reserves of base metals over the past few years suggest the significant need for increased exploration and development if Canada is to maintain its market share of the base metals in the next decade.

Overall, the prospects for the Canadian mineral industry in 1989 appear favourable. The encouraging gains of the past few years should enable the industry to maintain its new vitality, to meet the challenges of 1989 and to remain an important contributor to the economy of Canada.

CANADA, PRODUCTION OF LEADING MINERALS, 1987 AND 1988

	1987	1988P	Percent change 1988/1987	1987	1988P	Percent change 1988/1987
	(000 tonnes except where noted)			($ millions)		
Metals						
Nickel	189.1	213.9	13.1	1 273.0	3 256.0	155.8
Copper	794.1	721.6	-9.1	1 923.1	2 317.0	20.5
Gold (kg)	115 817.6	127 842.5	10.4	2 204.5	2 215.1	0.5
Zinc	1 157.9	1 253.6	8.3	1 475.2	2 064.6	40.0
Iron ore	37 701.8	38 742.3	2.8	1 395.6	1 388.1	-0.5
Uranium(U)(t)	13 612.2	13 233.0	-2.8	1 182.2	1 108.0	-6.3
Silver (t)	1 374.9	1 527.1	11.1	424.1	378.1	-10.8
Lead	373.2	333.7	-10.6	394.8	333.7	-15.5
Platinum group (kg)	10 930.5	11 458.1	4.8	181.8	171.9	-5.5
Molybdenum (t)	14 771.3	12 388.0	-16.1	126.3	107.7	-14.7
Nonmetals						
Potash (K_2O)	7 668.4	8 070.4	5.2	745.0	1 058.7	42.1
Sulphur, elemental	5 809.2	5 914.6	1.8	522.9	460.8	-11.9
Asbestos	664.5	705.0	6.1	238.0	268.4	12.8
Salt	10 129.1	10 974.6	8.3	238.6	257.5	7.9
Gypsum	9 093.9	8 521.7	-6.3	87.0	87.7	0.8
Sulphur in smelter gas	722.8	820.1	13.5	80.1	73.6	-8.1
Structurals						
Cement	12 603.2	12 610.6	0.1	997.2	1 012.6	1.5
Sand and gravel	278 546.4	276 064.0	-0.9	768.8	782.7	1.8
Stone	113 291.3	112 421.5	-0.8	583.0	601.3	3.1
Lime	2 330.1	2 535.2	8.8	167.6	189.9	13.4
Clay products	..	..	..	210.8	185.3	-12.1
Fuels						
Petroleum (000 m^3)	89 140.0	92 856.0	4.2	12 141.0	9 349.5	-23.0
Natural gas (million m^3)	78 267.0	87 893.0	12.3	4 615.1	4 973.3	7.8
Coal	61 211.0	69 500.0	13.5	1 641.3	1 907.8	16.2
Natural gas by-products (000 m^3)	21 560.0	22 332.0	3.6	1 876.3	1 609.5	-14.2

P Preliminary; .. Not applicable.
Note: Figures have been rounded.

CANADA, EXPORTS OF MINERALS, BY STAGE OF PROCESSING[1]

	1976	1981	1986r	1987	% change 1987/1986
	($ millions)				
Crude					
Ferrous	920.5	1 465.3	1 107.8	968.4	-12.6
Nonferrous	743.3	1 393.1	1 092.8	1 356.1	24.1
Industrial	1 131.1	2 682.2	2 841.2	2 703.6	-4.8
Fuels	4 531.4	8 201.3	8 316.5	9 330.4	12.2
Total	7 326.3	13 741.9	13 358.3	14 358.5	7.5
Scrap					
Ferrous	63.9	75.3	109.6	152.0	38.7
Nonferrous	105.5	313.9	434.2	530.0	22.1
Total	169.4	389.2	543.8	682.0	25.4
Smelted and refined					
Ferrous	115.6	475.1	278.0	219.2	-21.2
Nonferrous	2 654.2	5 836.5	7 973.2	6 472.1	-18.8
Fuels	728.7	2 800.2	2 578.1	2 616.2	1.5
Total	3 498.5	9 111.8	10 829.3	9 307.5	-14.1
Semi-manufactured					
Ferrous	742.1	1 874.8	2 171.9	2 483.7	14.4
Nonferrous	269.6	586.9	865.5	1 062.9	22.8
Industrial	327.2	711.1	982.1	1 015.9	3.4
Fuels	19.0	512.9	183.3	192.2	4.9
Total	1 357.9	3 685.7	4 202.8	4 754.7	13.1
Total mineral exports (including scrap)	12 352.1	26 928.6	28 934.2	29 102.7	0.6
Total domestic exports, all products	37 328.5	81 203.3	116 733.4	121 462.3	4.1
Crude minerals as % of exports, all products	19.6	16.9	11.4	11.8	
Total minerals as % of exports, all products	33.1	33.2	24.8	24.0	

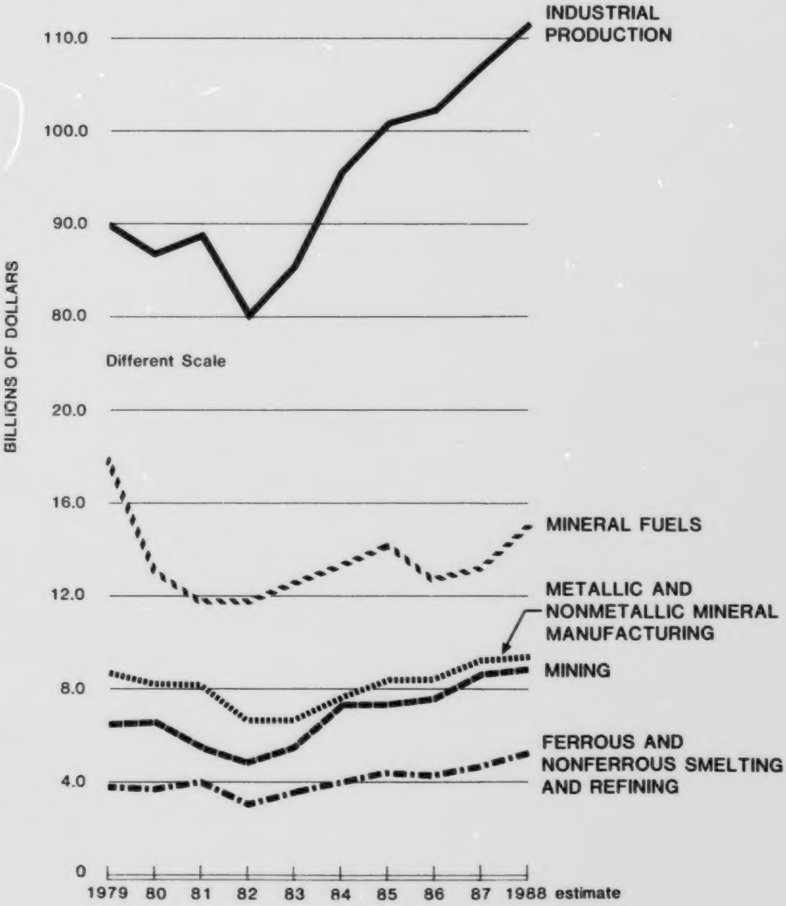
---

[1] The trade data was compiled on the basis of a mineral industry definition developed by the Mineral Policy Sector of EMR in 1977.

r Revised.

Figure 1

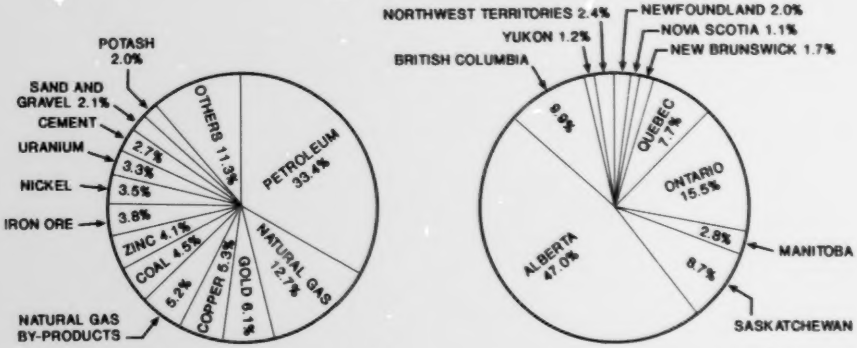
GROSS DOMESTIC PRODUCT AT 1981 PRICES



SOURCE: STATISTICS CANADA.

Figure 2

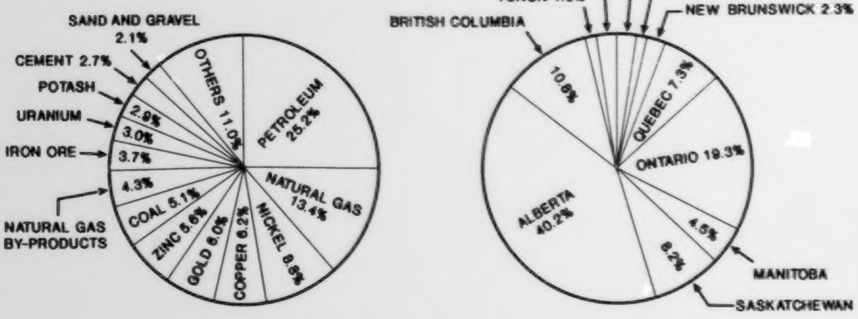
CANADA, VALUE OF MINERAL PRODUCTION, 1987



% OF TOTAL BY COMMODITY

% OF TOTAL BY PROVINCE

CANADA, VALUE OF MINERAL PRODUCTION, 1988



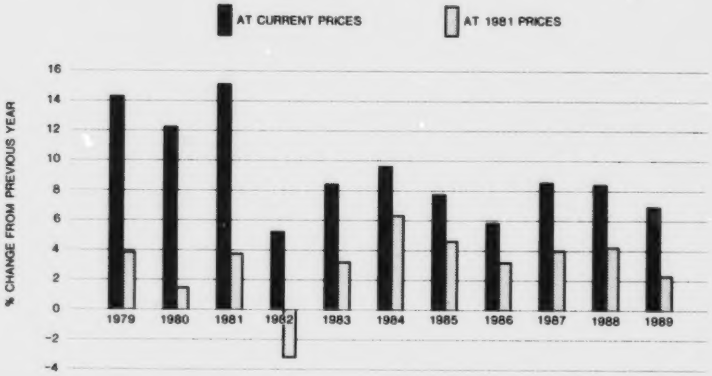
% OF TOTAL BY COMMODITY

% OF TOTAL BY PROVINCE

Figure 3

TRENDS IN CANADIAN ECONOMIC ACTIVITY

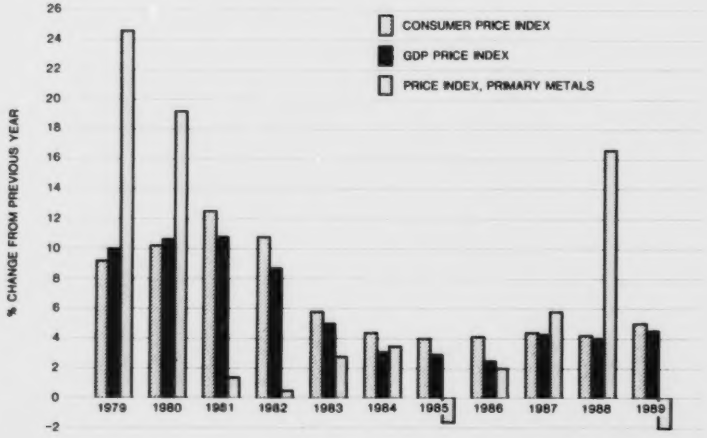
(% CHANGE IN GROSS DOMESTIC PRODUCT)



NOTE: FIGURES FOR 1988 AND 1989 ARE ESTIMATED.

Figure 4

GENERAL CANADIAN PRICE TRENDS



NOTE: FIGURES FOR 1988 AND 1989 ARE ESTIMATED.

International Review

A. BOURASSA

THE MINERAL AND METAL SITUATION

The highlight of 1988 has definitely been the virtually universal and often spectacular rise in the price of mineral commodities for the world mineral industry. The price of nonferrous minerals has made the headlines most frequently, but on the whole other mineral commodities have also had a good year. It is certainly not unheard of for an expanding economy to create conditions likely to strengthen the price of such commodities. The 1988 price rises are nonetheless remarkable because they were not only dramatic, but also sudden, occurring after prices had resolutely remained at often record lows in spite of five years of sustained economic expansion. The following paragraphs are an attempt to describe the factors behind these developments.

The 1981-82 recession was particularly difficult for the mineral sector. It began just as the industry's production capacity was recording marked growth, following very large investments in the late 1970s. Prices collapsed in many cases to record levels, forcing companies to make major adjustments to contain their financial losses. Marginal units of throughput were eliminated. Production plans for several mines were changed to concentrate activities on the richest zones thus shortening, in many cases, the useful life of these deposits. Investment was made to improve productivity and to cut production costs, not to expand. Activities yielding no immediate financial benefits, such as exploration, research and development (R&D) and technical support, were drastically reduced. Many skilled and experienced workers were laid off. Survival was of the essence.

The economic recovery that began in 1983 yielded no immediate benefits to the mineral industry. Demand increased once again, but the industry's excess production capacity was easily able to accommodate the growth. Prices stayed where they had fallen during the recession. The world economy thus experienced nearly five years of sustained expansion while enjoying low and stable mineral and metal prices. Nonetheless, the day was to come when this overcapacity would be absorbed. This is what began at the end of 1987 and continued in 1988. Two main factors explain the sudden, steep rise in prices.

For companies in the mineral sector, the recession did not end in 1982, but late in 1987. It therefore comes as no surprise that after seven years of costs reductions, just getting by and hearing many forecasts of an even bleaker future, the industry was hesitant and even poorly prepared to adjust to an expanding economy. It therefore entered 1988 with few or no expansion plans nearing completion. The few expansion plans in progress are recent, and one to three years will be required for full implementation. Furthermore, not only must mining production be stepped up to meet the increase in demand, but new plans are required to compensate for the accelerated depletion of reserves. Reserves have significantly dwindled since the recession, not only because of a decrease in exploration activity for metals other than gold, but also because of accelerated exploitation of zones producing the richest ore and premature closure of mines, such as the Pine Point mine.

Since 1981, exploration for minerals other than precious metals has fallen to very low levels, insufficient to ensure adequate reserves for the long term. An increasing number of company heads and analysts, moreover, are publicly voicing growing concern over the low level of reserves. A renewed effort to explore must be made, but it will of course be several years before significant results are obtained in terms of production. The markets have thus recorded very substantial price increases because the industry did not invest soon enough to meet the increased demand. In addition, there was another major change which contributed to the current situation in mineral markets.

A. Bourassa is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 995-6516.

A survey of the past decade indicates that the principal mineral and metal markets were considered to be in stable equilibrium when the overall stock level was around two and one half to three months of consumption. However, this time it was noted that prices shot up only when supplies dropped below the level of approximately one and one half months of consumption. This development seems to reflect a trend already identified in the manufacturing industry where stock levels are kept low using the just-in-time inventory system. This method cuts costs but also causes greater vulnerability to changes which may occur in the markets. When stocks are lower, any market disturbance could have more significant effects sooner. For this reason, the reduced stock level has contributed to the 1988 rise in prices and to their volatility.

Prosperity has therefore returned to the mineral industry in 1988 after a six-year absence. Current trends in supply and demand indicate that prices should remain at levels higher than the historical average for the short and probably the medium term (one to two years) unless of course another recession like that of 1981-82 occurs. A slowdown in economic growth would make prices drop, but they should not fall below satisfactory levels. Moreover, since most producers have significantly cut costs, profit margins are now larger at a given price level than they would have been in the past decade, for example. In spite of this bright outlook, the seeds of a more uncertain future may be sown if prices remain at current levels. Mineral commodities do not exist in a vacuum. On the contrary, both new and traditional markets must constantly be defended from a growing number of increasingly competitive substitutes. It is therefore imperative for producers to be capable of convincing their clients that they will be in a position to provide them, in the long term, with a sufficient supply at relatively stable and competitive prices. Otherwise, major market segments will soon be jeopardized. Increasing exploration expenditures is probably one of the most important steps that producers must take. Sufficient expansion downstream will only be possible if exploration receives sufficient funding now.

The situation described above applies more specifically to mineral commodities in the ferrous and nonferrous sector, with the exception in the first case of iron ore. The price of iron ore strengthened in 1988. Gains were, however, very modest because of the relative balance between supply and demand. In the area of major industrial minerals, potash has stood out. Potash prices have made notable gains, although less as a result of the play of market forces than because of an agreement reached between Canadian producers and the United States government to settle a dumping case. For more complete information, readers are encouraged to refer to the following chapters, which deal with the major minerals individually.

Against this background, a number of multilateral and bilateral events are worthy of note.

THE MULTILATERAL SCENE

In terms of international political initiatives under the auspices of the United Nations Conference on Trade and Development (UNCTAD), 1988 was the quietest year in more than a decade. This is in contrast to the UNCTAD VII meeting in 1987, and earlier debates on the New International Economic Order, the Integrated Program for Commodities, the Common Fund and international commodity agreements with economic provisions. Commodity specific proposals and initiatives such as for compensatory financing in the event of commodity export shortfalls have, one after another, been found to be technically, economically or politically unworkable. This is not to say that these and other issues will not be revived for further examination in the future.

One such phoenix is the Agreement Establishing the Common Fund for Commodities (the Common Fund) negotiated in the late 1970s. The last technical requirement for its legal entry into force (ratificiation by a number of countries representing two-thirds of its capital) was achieved in June 1988. It is a measure of the hesitancy surrounding the future of the Common Fund that the developing countries have not pressed for its immediate commencement of operations. Indeed, the first organizational meeting will not take place until July 1989 at the earliest. No matter what decisions are taken at that time, it is already clear that it will not serve its original function (to provide a pool of capital to aid the functioning of commodity agreements with price regulating mechanisms).

Study groups and other statistical or research and development bodies may benefit from the Common Fund. Although there were negotiations or discussions involving nickel, copper, iron ore and tin during the year, no significant progress was made. By contrast, the long-established International Lead/Zinc Study Group, currently under the chairmanship of Canada, continues to function well to the benefit of producers and consumers. The individual commodity reviews contain more information on these efforts.

The Convention on the Regulation of Antarctic Mineral Resource Activities was agreed to in May 1988 and opened for signature in November. There is no expectation that the Antarctic will be exploited for its mineral resources for at least several decades. It was felt, however, that there was now an opportunity (before economic interests were identified) to put in place appropriate protection for the unique Antarctic environment. Canada is examining the Convention and will decide within the next year whether to sign.

The Preparatory Commission for the International Seabed Authority that began its work in 1983, is continuing its examination of elements of a mining code for the deep seabed. In 1988 debate centered on the terms and conditions under which technology should or must be transferred. There is a mandatory element in the proposed transfer process, which is strenuously contested by a number of countries, including Canada.

The Uruguay Round of Multilateral Trade Negotiations (MTN) that was launched in September 1986 reached its mid-point in December 1988 in a ministerial level meeting hosted by Canada in Montreal. Largely as a result of a disagreement on the thorny issue of agricultural subsidies, progress achieved on other issues was temporarily put on hold. Negotiations are continuing and a senior officials meeting is planned for April 1989 in an effort to resolve the impasse on agriculture and resume progress on other aspects of the MTN. The Uruguay Round is scheduled for completion in 1990.

THE BILATERAL SCENE

The Canada-U.S. Free Trade Agreement

The Free Trade Agreement (FTA) came into force on January 1, 1989. Earlier in the year, the government published an assessment of the FTA for the minerals and metals industries. As indicated in last year's review, the FTA is considered to be a positive development for the Canadian mineral industry as a whole. With regard to tariffs, the FTA was negotiated using the Harmonized System of Tariff Nomenclature, which Canada implemented on January 1, 1988 and the United States on January 1, 1989.

Glasnost

Although this is a Russian word and it is the Soviet Union which occupied the greatest attention in 1988, it is descriptive of developments in both the Soviet Union and China. Although a discussion of the changes under way in these enormously important socialist economies is not suitable for this review article, it must be noted that there are profound implications for the functioning of the world mineral economy if the reforms under way and proposed are fully implemented in these two countries. There will be both opportunities and uncertainties for Canadian industry as a result.

For Canada, early results of glasnot have been very successful. There have been recent reciprocal nickel missions with the U.S.S.R. and the establishment of ferrous and nonferrous working groups with China.

TABLE 1. CANADA'S MINERAL[1] EXPORTS 1986 AND 1987, BY MAJOR MARKET AND STAGE OF PROCESSING[2]

	1986r				1987			
	United States	EEC[3]	Japan	Total	United States	EEC[3]	Japan	Total
				($ million)				
Crude								
Ferrous	508.2	526.8	44.5	1 107.8	425.2	466.7	43.9	968.4
Nonferrous	194.9	405.3	573.7	1 259.6	299.9	532.2	717.1	1 634.1
Industrial	871.5	558.6	1 432.4	4 692.2	928.2	490.3	1 311.4	4 373.6
Total	1 574.6	1 490.7	2 050.6	7 059.6	1 653.3	1 489.2	2 072.4	6 976.1
Scrap								
Ferrous	67.4	15.2	5.0	109.6	101.7	11.9	7.8	152.0
Nonferrous	288.7	93.7	28.4	434.2	373.1	82.2	37.3	530.0
Total	356.1	108.9	33.4	543.8	474.8	94.1	45.1	682.0
Smelted and refined								
Ferrous	174.8	74.0	11.6	278.0	141.7	55.8	7.5	219.2
Nonferrous	6 238.3	884.6	649.2	8 647.8	4 544.5	1 037.9	591.1	7 080.4
Total	6 413.1	958.6	660.8	8 925.8	4 686.2	1 093.7	598.6	7 299.5
Semi-manufactured								
Ferrous	1 976.4	29.1	1.2	2 171.9	2 242.3	17.7	1.4	2 483.7
Nonferrous	658.4	112.9	34.1	865.5	843.0	112.1	36.0	1 062.9
Industrial	929.8	17.1	4.7	1 000.3	941.8	30.9	7.8	1 041.4
Total	3 564.6	159.1	40.0	4 037.7	4 027.1	160.6	45.2	4 588.0
Grand total (excluding scrap)	11 552.3	2 608.4	2 751.4	20 023.1	10 366.6	2 743.5	2 716.2	18 863.6
Percentage of grand total	57.7	13.0	13.7		55.0	14.5	14.4	

---

[1] Includes uranium and coal but excludes petroleum and natural gas. [2] The trade data compiled on the basis of a mineral industry definition developed by the Mineral Policy Sector, EMR in 1977. [3] EEC: Belgium, Denmark, France, West Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, United Kingdom and Greece.
Totals may not add due to rounding.
r Revised.

TABLE 2. CANADA'S MINERAL[1] IMPORTS 1986 AND 1987, BY MAJOR MARKET AND STAGE OF PROCESSING[2]

	1986				1987			
	United States	EEC[3]	Japan	Total	United States	EEC[3]	Japan	Total
				($ million)				
Crude								
Ferrous	271.1	...	0.1	294.5	248.5	...	-	257.9
Nonferrous	641.1	17.1	-	869.2	340.1	22.4	-	569.2
Industrial	1 037.3	22.7	0.1	1 097.9	1 046.0	15.8	...	1 107.1
Total	1 949.6	39.9	0.2	2 261.6	1 634.6	38.2	...	1 934.2
Scrap								
Ferrous	66.0	...	-	66.1	74.9	0.1	-	75.2
Nonferrous	204.8	19.3	0.2	367.6	227.7	13.2	-	337.4
Industrial	1.0	-	-	1.0	1.4	-	-	1.4
Total	271.8	19.3	0.2	434.7	304.0	13.3	-	414.0
Smelted and refined								
Ferrous	71.4	77.7	...	212.0	88.8	168.2	...	353.8
Nonferrous	2 127.7	103.2	63.3	2 672.5	1 287.9	97.2	26.6	1 994.0
Total	2 199.0	180.9	63.3	2 884.5	1 376.8	265.4	26.6	2 347.8
Semi-manufactured								
Ferrous	715.7	482.8	193.3	1 672.2	796.6	507.0	171.0	1 774.1
Nonferrous	774.2	113.5	21.4	960.8	925.0	124.4	18.3	1 117.2
Industrial	986.6	309.2	56.5	1 477.4	1 054.2	357.7	38.7	1 601.6
Total	2 476.6	905.5	271.2	4 110.4	2 775.8	989.1	227.9	4 492.8
Grand total (excluding scrap)	6 625.2	1 126.2	334.7	9 256.5	5 787.2	1 292.7	254.5	8 774.8
Percentage of grand total	71.6	12.2	3.6		66.0	14.7	2.9	

---

[1] Includes uranium and coal but excludes petroleum and natural gas. [2] The trade data compiled on the basis of a mineral industry definition developed by the Mineral Policy Sector, EMR in 1977. [3] EEC: Belgium, Denmark, France, West Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, United Kingdom and Greece.

... Amount too small to be expressed; - Nil.

Totals may not add due to rounding.

Regional Outlook

H.R. WEBSTER

The value of production of metals, nonmetals, structural materials and coal in 1988 was $21.1 billion, an increase of $3.4 billion, or 19.4% over 1987. Each of the sectors showed increases: metals by 25.8%; nonmetals by 12.5%; coal by 16.2%, and structural materials by 1.6%. When natural gas, natural gas by-products and crude petroleum are included, the value of production was $37.1 billion, an increase of 2.0% over 1987.

The focus of exploration on gold over the past several years has created a crisis in base metals reserves. This problem must be addressed in Canada to maintain our national production levels and world market shares. Innovative prospecting methods, utilizing provincial and federal geoscience data bases, are required in regions of known high potential as well as in previously unexplored and under explored areas.

Since 1969, federal-provincial Mineral Development Agreements (MDAs) have played an important role as a cooperative instrument of regional economic development. They have proven to be a highly effective means for combining the financial resources and expertise of the two levels of government. The earlier MDAs were chiefly dedicated to a revision of provincial geoscientific data bases, as a stimulus to mineral exploration by industry in various parts of Canada. Current MDAs, mostly with five-year terms, were planned in 1983 and 1984 when the industry was suffering from a serious economic crisis and thus cover a much broader scope. Some of the programs have evolved to include industry participation in the planning, review and funding of program components. These MDAs are approaching the end of their terms. They have yielded a broad range of benefits and are highly regarded by their principal client, the mineral industry. This industry is in a much healthier state than in the early 1980s, but world competition is still keen, and governments have a logical role to play in the industry's future and the continuing economic state of the regions of Canada.

ENVIRONMENTAL ISSUES

The theme of the 1988 Mines Ministers' Conference was "The Environment". This signifies the deep concern within the industry for environmental quality. Concepts in the report of the World Commission on Environment and Development (the Bruntland Commission Report), and the need to integrate economic and environmental planning to achieve sustainable economic development, provided a basis for discussion. The Bruntland approach has been welcomed by industry and government because it recognizes that improving environmental quality begins with economic development. The conference entertained discussion on the definition and implementation of environmentally sustainable economic development as it applied to discovery and production of minerals.

The industry has identified acid discharge from mine waste as the most difficult and widespread environmental problem that it faces. A sub-committee of the Intergovernmental Working Group submitted a report on the economic and policy aspects of controlling acid discharge. Using existing but unsatisfactory technology, industry estimates that it would have to spend $150 million/y over the next twenty years to bring the problem under control. The ministers accepted the report and planning by federal and provincial governments to implement the recommendations is well under way. For instance, Ontario has incorporated a number of the recommendations in its Green Paper on the mining industry released on December 12, 1988. Industry has identified funding for the research program described in the report, Mine Environment Neutral Drainage (MEND). The Canada Centre for Mineral and Energy Technology (CANMET) is project co-ordinator.

On June 30, 1988, Parliament proclaimed the Canadian Environmental Protection Act (CEPA). The act consolidates certain existing federal environmental statutes and powers including the Ocean Dumping Control

---

H.R. Webster is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 995-9053.

Act, the Environmental Contaminants Act, the Clean Air Act, the nutrients part of the Canada Water Act and the powers to establish environmental guidelines for federal departments and agencies from the Department of the Environment Act. Its core is a system for identification, assessment, scheduling, and ultimate regulation of toxic substances. Unlike the preceding legislation, CEPA contains provisions for criminal prosecution in cases where abuse of the environment is flagrant.

According to a recent decision by the Supreme Court of Canada involving the Ocean Dumping Control Act, the federal government has significant jurisdiction in environmental matters under its powers of peace, order and good government (POGG). Besides shoring up CEPA, this decision may also give the federal government some indirect leverage in provincial natural resource development and management.

The department has a mandate to manage mineral resources in offshore areas of federal jurisdiction for which the Minister of Energy, Mines and Resources Canada (EMR) has administrative responsibility. The Ocean Mining Division of Mineral Policy Sector (MPS) has undertaken to develop legislation covering offshore mining. This exercise has and will continue to involve extensive consultation and close co-operation with provincial governments (including the minerals, fisheries and environmental sectors), with the Department of Fisheries and Oceans (DFO) and with Environment Canada as well as with the mining and fisheries industries.

The federal government has announced that the environment will be a priority of the next mandate. In 1988, the department developed an environmental policy covering its own activities. This is now being refined to complement overall federal government policy. EMR will also be devoting resources in the earth sciences and energy sectors to study larger environmental issues such as changes in the composition of the atmosphere and to present policy options to deal with the possible national and global impacts of a warmer climate.

NEWFOUNDLAND

The mineral industry of Newfoundland and Labrador accounts for 40% of the value of primary resources of the province and 12% of Gross Provincial Product. In 1988, the value of mineral production increased to $888 million, of which $727 million was for iron ore, $27 million was for asbestos and $49 million was for zinc.

The boom in exploration continued; encouraged by gold discoveries on the south coast and on the Baie Verte Peninsula, prospectors made gold their major target in 1988. For the fifth year in succession, expenditures reached record levels, increasing to about $40 million. New records in numbers of claims staked (21 000), claims held in good standing (62 000), and metres diamond drilled (more than 100 000) recorded in 1988 indicate that mineral exploration in Newfoundland and Labrador is in a period of sustained growth. Mineral exploration is now an important industry in itself, employing 500 people in all regions of the province.

The rapidly expanding geological data base generated under the Canada-Newfoundland MDA is showing explorationists high potential target areas and providing an improved understanding of gold environments. Benefits of this increase in geoscience information are demonstrated by an increase in the number of mineral deposits. Four new discoveries on the Baie Verte Peninsula, coupled with the success of Hope Brook gold mine, are encouraging industry to recognize Newfoundland as a major new area for gold exploration.

While the province has a long history of base metal production, only Newfoundland Zinc Mines Limited's mine at Daniel's Harbour is currently in production. Even on this property, reserves are nearly exhausted and the mine will close in the spring of 1989, despite the recent discovery of a new ore zone. More optimistically, there has been a rising interest in base metal exploration for several years. A production decision by Noranda Exploration Company, Limited on the Duck Pond polymetallic deposit near Buchans is expected in 1989 and $3.84 million will be spent on the old Rambler property. The work will be done by the Joint Venture (Teck Corporation, Petromet Resources Limited and Newfoundland Exploration Company Limited) that acquired the property under the provincial mining law, by which properties revert to the Crown if not worked for 5 years.

Industrial minerals currently account for $77 million/y, 8.5% of the value of minerals produced in the province. Growth in this sector is aided by the province's strategic location and proximity of various deposits to tidewater. A number of these favourably located deposits are being developed to meet ever increasing U.S. demand. The Lower Cove aggregate operation on the Port-au-Port Peninsula is one such deposit and will begin production in March 1989. Planned output is 4 Mt/y.

In Labrador, two high purity quartzite deposits examined under an MDA project show excellent potential for development and local processing. One could lead to production of silicon metal in the Labrador City area. The other, held by Blue River Mines Ltd. and Ekaton Industries Inc. could produce 60 000 t/y of high-purity glass sand. Recent publications have stimulated new interest in the chatoyant labradorite-bearing anorthosites near Nain for possible use as dimension stone. Interest being shown by industry towards Labrador mineral deposits other than iron ore is an encouraging indication of diversification in this area.

Iron ore is the province's mainstay in mining, 82% of the value of total production in 1988. Wabush Mines and Iron Ore Company of Canada (IOC) produced 20 Mt in 1988. No increase in production is foreseen in the medium term.

The $22 million Canada-Newfoundland MDA will end March 31, 1989. To date the MDA has had notable successes. Completion of regional mapping in Newfoundland and Labrador, new understanding of gold environments and identification of high-quality silica deposits are highlights of the Geoscience program. The Mining Technology program has resulted in improvements in pellet production technology and iron ore recovery techniques. Several building stone deposits have been assessed and samples made available to architects and the industry.

The Mineral Industry Assistance Program (MIAP), launched in 1988, provides assistance to the industry for market and feasibility studies, infrastructure for nonmetallic mineral operations and grants for an assistance program to prospectors. The MIAP has received a number of proposals and has already provided infrastructure assistance to an industrial mineral deposit in eastern Newfoundland.

NOVA SCOTIA

In 1988, the value of mineral production, including coal, in Nova Scotia increased by 13.4% over 1987 to $461 million.

An estimated $30 million was spent on mineral exploration in 1988, down from the estimated $45 million of 1987 but still representative of a high degree of activity. Exploration diamond drilling was brisk until mid-year, totalling 95 300 metres, then slowed and is not expected to reach the 215 000 m recorded in 1987. Total new claims staked showed a moderate decline to an estimated 30 000, down from 39 639 in 1987. The reduced activity is interpreted as a reflection of uncertainty about the proposed modification of the flow-through share method of financing mineral exploration, and the hesitancy of investors following the market adjustment in October 1987. Specific to gold exploration, the slump is believed to be temporary and possibly compounded by the lawsuit brought against the former directors of Seabright Resources Inc., as well as a downturn in the international price of gold. However, some 28 junior exploration companies are active in the province exemplifying the continuing interest in gold.

Gold exploration focussed, for the most part, on known gold occurrences with several properties reaching advanced stages. Exploration Orex Inc. hope to bring their Guysboro County gold project to production by September 1989. Coxheath Gold Holdings Limited, having received its mining lease, is gearing up for full production at its Tangiers gold property, with plans to use a variation of the resueing method to mine the narrow-veined Meguma-hosted deposits. If the technique is successful, application to other small but rich pockets of gold mineralization can be foreseen both in Nova Scotia and elsewhere. It can be anticipated that these and other gold properties in the province will provide local employment and the consequent economic benefits.

Rio Algom Limited re-acquired control of the East Kemptville tin mine, the only primary tin producing mine in North America. A very high grade by-product topaz is being viewed as a promising commodity and represents the possibility for further diversification of the Nova Scotia mineral industry.

The industrial minerals industry in Nova Scotia continued to expand in 1988, showing a 10.3% increase over 1987 for a total value of $213.4 million, representing 46.3% of the value of mineral production, including coal. By taking advantage of its seaport facilities and geographical location, as well as the quality and quantity of its deposits, Nova Scotia is in a position to compete in the markets of the United States, the Caribbean, Western Europe, the Middle East and Japan, as well as other parts of Canada. With funding from the Canada-Nova Scotia MDA, a delegation from the provincial Department of Mines and Energy promoted the industrial mineral wealth of Nova Scotia through a presentation and display at the 8th Industrial Mineral International Congress in Boston in April.

Outlook for the gypsum industry, second to coal in value, remains positive although a decline is possible in 1989 in response to a general slowing down of the North American construction industry. As well, the Nova Scotia gypsum industry is facing stiff competition in U.S. markets from offshore producers, particularly from Spain. Major producers, National Gypsum (Canada) Ltd. and Fundy Gypsum Company Limited, together with smaller scale operations are continually upgrading facilities to remain competitive and outlining additional reserves. Louisiana-Pacific Corporation of Portland, Oregon, announced plans in November to establish a $65 million fibre-gypsum board plant at Point Tupper on Cape Breton Island. Construction is to be completed early in 1990. The paperless wallboard, using local gypsum, recycled paper and perlite, will be shipped from the Strait of Canso to the eastern United States seaboard.

Building stone investigations under the MDA have led to increased interest in the use of Nova Scotia stone for building restoration and new construction. A successful MDA-funded Stone Restoration Mason Apprenticeship Training Program has provided a qualified workforce for the restoration of provincial heritage buildings. With identification of suitable provincial deposits and perfection of the stone masonry skills, the possibility exists for expansion of building restoration programs outside of Nova Scotia. In September, Granitile Inc. of Concord, Ontario announced plans to establish a granite tile manufacturing plant at Port Hawkesbury. Commercial production is expected by August 1989. The company hopes to claim a part of the North American granite tile market, now supplied 90% by imports.

Nova Scotia coal production increased 16.9% over 1987 to 3.4 Mt for a value of $208 million. Cape Breton Development Corporation (CBDC) has been involved in researching new technologies to facilitate utilization of Cape Breton coal and address the high sulphur problem. Research on coal-water fuels resulted in the installation at Minas Basin Pulp and Power Plant at Hantsport of the first commercial boiler to use coal-water fuel. However, at year-end, CBDC was forced to cut its supply of coal-water fuel in accordance with an option to cut supply if the world price of oil dropped below US$20-21/bbl.

Westray Coal Inc. reportedly plan to begin work in January 1989 on an underground thermal coal mine in Pictou County. The low sulphur bituminous coal is expected to meet specifications of the Nova Scotia Power Corporation (NSPC) coal-fired electric generating station near Trenton, 11 km distant.

The Canada-Nova Scotia MDA was in the fifth and final year in 1988. Most geoscience projects are now at the final report and publication stage. Innovative market, feasibility and commodity studies have been a major component of the MDA and were well-received by the industry. Through the Mineral Investment Stimulation Program (MISP) the private sector continued to benefit from the financial assistance directly available to advance qualified projects and further enhance economic potential. Over the past five years the MDA has played a major role in the development of a strong provincial mineral economy.

NEW BRUNSWICK

In 1988, the value of mineral production, including coal, increased over 1987 by 33.6% to $831 million. Zinc with an increase in value of 65%, accounted for $379 million.

Preliminary exploration expenditures, based on the value of assessment work received, are estimated by the provincial government to be $8.4 million in 1988, an increase of 27% over 1987. Exploration in 1988 was dominated by gold interest. A major incentive to exploration was the introduction by the New Brunswick Department of Natural Resources and Energy of the Mineral Exploration Stimulation Program (MESP). Funding of up to $10 000 per project for exploration within the province, was approved for 31 out of 48 applications received, and totalled $200 000. Exploration was further spurred by the availability of outputs produced under the Canada-New Brunswick MDA, and the appointment of a Mining Commissioner with the power, among other things, to resolve disputes, emphasis being placed on improved land owner liaison, environmental issues, and a simplification of staking and reporting procedures. The number of claims recorded during 1988 was up to 6 936 from 4 500 in 1987. Provincial and MDA participation at the Prospectors and Developers Association of Canada meeting in March is credited with a significant staking rush in the Jacquet River volcanic-sedimentary belt in northeastern New Brunswick in April and May.

Although base metal prices have been strengthening and both industry and EMR have flagged lowered national base metals reserves as a serious concern, this has not yet been reflected in exploration activity in New Brunswick. The Bathurst area hosts four known premier massive sulphide deposits and is a logical target for increased base metal exploration. Within this area, East West Caribou Mining Limited is gearing up for production of a bulk Zn/Pb concentrate from the former Anaconda property. The company received a mining lease at the end of October, and expect to be processing ore early in 1989. Brunswick Mining and Smelting Corporation Limited is in the final stages of a study to determine the feasibility of mining the Stratmat deposit together with the B and E zones of the adjacent Heath Steele deposit. A production decision is expected after mid-February 1989. Feed would be run through the Heath Steele mill, last operated in 1984. Thus it would appear that renewed interest in re-opening the mill and the possibility of blending new and known reserves of ore may lead to major base metal exploration and development activity.

The merger of Northumberland Mines Limited with NovaGold Resources Incorporated in February made possible further development of the Murray Brook gossan-type gold deposit near Bathurst. Production is expected when financing arrangements are complete, which will make Murray Brook the second gold mine in operation in New Brunswick, the first being the Cape Spencer open-pit mine near Saint John.

Landmark Corporation, operators of the Lake George antimony mine which accounts for over 10% of the world's antimony production, enjoyed the benefits of a strong antimony market. New reserves have been defined. As well, a separate and distinct gold-bearing skarn stockwork paralleling the antimony vein structure has been identified at depth, adding a new dimension to exploration drilling and evaluation.

The two potash mines continued to operate throughout the year. Both companies hope to take advantage of the all-weather port of Saint John and a good rail and road infrastructure to increase markets along the eastern seaboard of the United States and other offshore destinations.

As further evidence of the diversification of the New Brunswick mineral industry, seventeen peat bogs were in production with several more under development. Companies are looking at new products and expanded markets, some of the interest having resulted from MDA technical and market studies.

The Canada-New Brunswick MDA was in its fifth and final year in 1988. Projects completed during the year included the publication of maps of airborne gamma-ray spectrometer, VLF and aeromagnetic gradiometer surveys. Reports issued include studies on mineral aggregates, offshore mining, peat moss markets, and an evaluation of industrial minerals markets in the east coast area of the United States. Multi-year projects nearing completion include evaluation of aggregates for alkali reactivity, potash mineralogy, backfill techniques in potash mining, non-destructive testing of wire ropes, and the use of CO_2 as a monitor in mine ventilation systems.

QUEBEC

In 1988, the value of mineral production in Quebec was $2.7 billion, representing a decrease of 2.3% compared to 1987. The decrease is attributable to diminished production of copper and silver. Iron ore production remained at about the same level as last year, 15.7 Mt, which can be considered, taking into account markets and profitability of mining operation, an optimum rate of production.

The level of employment decreased from 21 452 in 1987 to 19 480 in 1988. The change was most notable in the drilling sector where the number of jobs dropped from 1 507 in 1987 to 1 200 in 1988.

Exploration expenditures dropped from the 1987 all time high of $467 million to $371 million in 1988. Of this, approximately $200 million was funds raised the previous year and spent in the first two months of 1988. The remainder thus represents a significant slow-down in exploration activity through the balance of 1988. The stock market crash of October 1987 combined with the absence of major discoveries, have reduced investor interest in speculative stocks and consequently the funding raised for exploration. The relatively low level of exploration is expected to continue through 1989 as market uncertainties and rising interest rates render unlikely a major change of investor attitude.

Many new mines came into production in 1988 and it is expected that the same pattern will repeat itself in 1989. Although a major share of exploration expenditures was channelled to the search for gold in past years, a significant portion of the new mining operations were in base metal or industrial mineral sectors as the consequence of earlier discoveries.

Assuming a stabilization in prices of minerals and metals, the outlook for the industry in the next three to four years appears to be excellent. The long term outlook, is more uncertain. Many old polymetallic deposits are becoming exhausted while the ones coming into production shortly have a life expectancy of 4 to 7 years. As it usually takes from 5 to 10 years to go from a discovery to production, and as no new base metal deposits have been discovered recently, we can surmise that copper, zinc and silver production in Quebec will begin to drop sharply in 4 or 5 years. As long as almost all of exploration expenditures (85-90%) continue to be channelled into the search for a single commodity, gold, the consequences could be dramatic. From today's vantage point, the mineral industry of Quebec could evolve into one that is overly dependent on the performance of three commodities, gold, iron ore and asbestos. Each of these commodities faces its own difficulties stemming from fluctuating prices (gold), to keen competition (iron ore), and regulatory pressures (asbestos).

The Canada-Quebec MDA now in its fourth year, invested more than $20 million in 1988 on projects related to geoscientific and mineral exploration, to the defence, promotion and R & D on asbestos and to financial support to industry for infrastructure and studies. One major achievement was the favourable conclusions of a study that shows, at a laboratory scale, that it is feasible and economic to produce magnesium metal from asbestos tailings. Further work on this concept will be done under a $9 million feasibility study that may lead to the construction of a $400 million plant and the creation of more than 300 jobs in the depressed asbestos region of Quebec.

Under a four-year $5.5 million Prospector Assistance Program in the Gaspé, many promising gold and base metal occurrences were discovered during the summer of 1988 and in some cases optioned to exploration firms by participating prospectors.

ONTARIO

In 1988, the mineral industry continued as one of the two most important primary industries supporting the provincial economy. Total value of mineral production was $7.2 billion, an increase of 27% over 1987, reflecting significant price increases in nickel, copper and zinc. Metals, almost all of which are produced in northern Ontario, accounted for $5.5 billion. Southern Ontario benefited from increased values for stone, sand and gravel and construction materials; production was worth $1.3 billion, reflecting the current building boom.

The exploration and development industries also had a banner year. Most of the work was focussed on gold. Activity was divided between areas having little history of gold mining, such as Mishibishu Lake, where more than 10 companies are pursuing exploration and development programs, and long established gold mining areas such as Timmins-Chapleau and Kenora-Fort Frances. The latter benefited from geoscientific programs carried out under the Canada-Ontario MDA which were specifically designed to assist these areas diversify and expand their mining base. New mines such as the Holt-McDermott gold mine opened, near Kirkland Lake and old reactivated properties, the Kremzar and Magino gold mines at Wawa, also began production.

Established mining areas also saw an increase in interest in reprocessing old tailings. At Timmins, ERG Resources Inc. have begun treatment on 140 Mt of previously-milled material. At Kirkland Lake, Eastmaque Gold Mines Ltd. began the country's first commercial tailings retreatment project in June. Improvements in recovery technology and high gold prices will likely make this form of gold production more common.

Mining, smelting and refining account directly for 10% of northern Ontario employment and a further 30% of employment is dependent on the industry. Despite the increase in gold mining and exploration, the bulk of this employment remains in base metal mining.

Nickel producers, INCO Limited and Falconbridge Limited, which dominate employment in the Sudbury district, experienced rising nickel prices and for the first time in years new staff was hired. Other base metal mining is centred around Timmins where Kidd Creek mine produces about 60% of Ontario's zinc. Minnova Inc.'s Winston Lake high-grade zinc mine, the province's first new base metal mine in eight years, started production near Schreiber in 1988.

Rio Algom Limited and Denison Mines Limited produced about 40% of Canada's uranium at Elliot Lake where the companies provide a stable employment base. Output levels are expected to increase only marginally as the market for uranium improves under the Free Trade Agreement with United States.

The $30-million Canada-Ontario MDA is in the fourth of five years. More than 250 projects are in progress or have been completed to date. Reports and maps produced by the Geological Survey of Canada (GSC) and Ontario Geological Survey (OGS) have been a major factor in increasing the level of exploration and their impact will continue to be felt for many years. The Productivity and Technology program, designed by EMR's CANMET in cooperation with industry, is being implemented entirely by mining companies under contract. Results of projects on backfill techniques and bulk mining at depth have reduced mining costs and increased safety and productivity that will help all mining companies. MDA Economic Development projects have stimulated and increased interest for several industrial mineral commodities, such as clays for fine china and various products for advanced ceramics.

In December 1988, Ontario Minister for Northern Development and Mines, Sean Conway, introduced a Green Paper recommending 49 changes to the Ontario Mining Act. New staking practices, streamlined procedures for mining development and measures to minimize claim disputes are included. The revised Act will meet the needs of modern day exploration and mining.

MANITOBA

In 1988, the value of Manitoba's mineral production increased by 68.0% over 1987 to $1.68 billion, of which $1.09 billion was for nickel, $171 million was for copper, and $94 million was for zinc.

Mining provides the principal economic base for the communities of northern Manitoba. In the early 1980s, low metal prices and declining ore reserves and grades caused intermittent mine closures and threatened the existence of several communities. In response, government and industry took measures to discover and develop new mineral deposits and reduce production costs. These initiatives have contributed to maintaining exploration expenditures close to 1987 levels at an estimated $50 million in 1988.

Many of these initiatives can be attributed to the five-year $24.7 million Canada-Manitoba MDA, which entered its fifth and final year in 1988. A mid-term, independent evaluation concluded that the geoscientific outputs were resulting in more effective and efficient exploration; research and development projects were contributing to improved mining, mineral processing and safety technology at existing mines; economic development studies were helping to identify potential building stone deposits, assess the economic impact of mining on the Lynn Lake area, forecast zinc concentrate supply and assess the market potential for feldspar. The MDA also enabled Manitoba Energy and Mines to computerize its mining recording section to meet the needs of the industry for fast, accurate record-keeping and retrieval of technical information. Thus, it would appear that the MDA made a significant contribution to strengthen and diversify the Manitoba mineral industry.

Economic security improved for several northern mining communities during 1988. At Lynn Lake, gold production at the MacLellan mine was increased by conversion to a more efficient mining method, and additional potential ore reserves were explored on nearby properties. At Leaf Rapids, the evaluation of copper-zinc deposits by Hudson Bay Mining and Smelting Co., Limited (HBMS) near the Ruttan mine could add three more years of ore reserves. In the Flin Flon area, HBMS and Outokumpu Mines Ltd. opened a nickel-copper mine and concentrator at Namew Lake, which will increase the supply of concentrates to Manitoba smelters. HBMS also will develop the Callinan zinc-copper property at Flin Flon, which will provide over 100 jobs when in full operation by the end of 1989. In the Snow Lake area, HBMS is preparing the Chisel Lake zinc-copper mine crown pillar for open-pit mining, and has outlined an additional 2.5 Mt of probable ore reserves underground.

Job security and the long-term viability of the Thompson nickel mining and smelting operations were further enhanced as a result of INCO Limited proceeding with development of the Thompson Open Pit South mine and reactivation of the Birchtree mine.

At Lac du Bonnet, Tantalum Mining Corporation of Canada Limited (TANCO) has constructed a spodumene concentrator at its Bernic Lake operation. This new plant will permit simultaneous production of both tantalum and spodumene, and thereby help secure the company's future as a major world supplier of these minerals.

SASKATCHEWAN

In 1988, the value of mineral production decreased by 3.3% over 1987 to $3.05 billion. The principal commodities after the petroleum industry are uranium at $585 million and potash.

The five-year, $6.38 million Canada-Saskatchewan MDA entered its fifth and final year in 1988. An independent evaluation of the first four years of the MDA concluded that the geological mapping, airborne gradiometer surveys and lake sediment geochemical surveys helped to stimulate approximately $49 million of new exploration activity and accelerated approximately $19 million of existing exploration programs. In cooperation with the Saskatchewan Potash Producers Association, MDA research and development programs contributed to a greater understanding of measures to prevent brine inflow and to improve separation methods for possible application in new or modified processing plants. Economic development work identified potential building stone deposits, promoted the use of potash, and assessed aggregate resources in several rural municipalities. Overall, the MDA has made a major impact towards strengthening and diversifying the Saskatchewan mineral industry.

In northern Saskatchewan, 1988 exploration and development expenditures for gold and other precious metals were approximately $45 million. Near the Star Lake gold mine, Corona Corporation and International Mahogany Corp. initiated production in November at their Jolu 400 t/d gold mine and mill. North of Lake Athabasca in the Beaverlodge area, gold and platinum group mineralizations were explored for precious metal potential. West of Flin Flon, exploration for and evaluation of base metal deposits resulted in an encouraging copper-zinc discovery at Hanson Lake. These and other projects provided greater employment opportunities for the residents of northern Saskatchewan.

In the Athabasca Basin, uranium exploration and development expenditures were about $44 million in 1988 despite continuing low prices for uranium. On the eastern edge of the Athabasca Basin, Cigar Lake Mining Corporation began a $40 million project to test methods for mining the Cigar Lake deposit. Cameco - A Canadian Mining & Energy Corporation received regulatory approval to develop the Collins Bay A and D orebodies and to initiate underground exploration and test mining of the Eagle Point deposits. Denison Mines Limited was granted approval for an $18 million project to test mining methods at its Midwest Lake uranium deposit. These projects will provide major employment opportunities starting with the mine and concentrator construction phase and continuing thereafter during the operating phase.

Near the end of 1988, there was considerable media speculation related to the search by Monopros Limited, an affiliate of De Beers Consolidated Mines, Limited for diamonds in the Prince Albert area. A number of other companies have staked a total of about 170 000 hectares in an extended area from Shellbrook in the west to Choiceland in the east. Exploration over this large area should create economic opportunities for the support industries of the Prince Albert area.

The Potash Company of America division of Rio Algom Limited is in the process of salvaging its flooded mine near Patience Lake, out of production since February 1987, by converting to a solution mining operation. Application of this new technology, when the conventional mines are depleted, would greatly extend the life of existing mining areas.

Early in 1988, the U.S. Department of Commerce agreed to suspend an anti-dumping action after the Canadian potash producers agreed to raise their prices for potash sold to the United States. Mainly as a result of the higher prices, the value of potash sales improved during 1988; however, shipments still remained low causing mines to operate much below capacity.

ALBERTA

In 1988, the value of mineral production was down 12.7% to $14.9 billion, largely the result of a 13% decrease in the value of some of the mineral fuels produced. Sulphur accounted for $420 million.

Buoyant international demand for coking coal stimulated record production by mines in Alberta. As well, production of subbituminous coal for mine mouth thermal power plants has increased. To support this increase a new thermal coal mine near Edmonton began production. Total production of coal increased 13.7% in 1988 and is likely to continue to increase for the foreseeable future.

Elemental sulphur is a by-product of sour natural gas and oil sands petroleum production and is a major component of Alberta mineral production. Shipments of elemental sulphur increased 13% to reach 7.6 Mt in 1988. Stronger demand for sulphur resulted in higher rates of remelting from above-ground vatted stocks, which will not be available by the early 1990s. About 29 000 jobs can be attributed directly and indirectly to sulphur in Alberta. Ninety percent of the Alberta production is exported to American and offshore markets for use in fertilizers and industrial processes. New sour natural gas, oil sands and heavy oil projects are expected to come on-stream in the medium term offsetting the rapid depletion of inventories and keeping Alberta a major supplier in the world merchant sulphur market.

BRITISH COLUMBIA

In 1988 the value of mineral production, including fuels, was up 10.5% to $3.99 billion. Approximately 40% of this value is attributable to mineral fuels (including $1.1 billion for coal), with almost half of the remainder of the value coming from copper production. Increases resulted from production from new gold mines, and increased prices for zinc, copper and coal.

The B.C. and Yukon Chamber of Mines reported that companies spent approximately $160 million on exploration in 1988. This is slightly lower than the record high of last year, but still above the expenditure levels previous to 1987.

Although a large portion of the exploration funds were spent on the search for gold in the province, a number of non-gold developments were under way, promising to keep the British Columbia industry diversified. Cassiar Mining Corporation has started work on the McDame Extension, adding to the life of its asbestos mine. Several polymetallic deposits, as well as talc, gypsum, and coal projects are being considered in the B.C. Mine Development Review Process. Work on several of these deposits, including the Windy Craggy copper deposit, and the Samatosum copper-silver deposit, continued to show encouraging results and promise for additional base metal production. Operating mines continued to expand reserves. Additional ore located at the Bell copper mine near Granisle should extend the life of this mine until 1992. Afton Mines Ltd. announced that it will develop the Ajax deposit, extending the life of the Afton copper mine by seven years.

Mineral exploration work in Strathcona Park became a contentious environmental issue. Drilling on claims, held since the late 1960s, sparked a public debate on mineral exploration in provincial parks. In response, the provincial government decided to ban new mineral development in Strathcona Park and will compensate the claim holders. The outcome of this conflict confirms that conservation measures will increasingly affect mineral industry production capacity.

Early in 1988, the British Columbia government passed a new Mineral Tenure Act. This Act streamlines the process for gaining placer rights and increases the land available for placer staking. At the same time, environmental protection safeguards are reinforced by increased monitoring and inspection. Protection for property owners is provided through the Mediation and Arbitration Board.

Direct employment in operating mines in British Columbia is approximately 14 000. While increased mechanization and consolidation of operations, such as at Highland Valley Copper, is reducing the number of jobs, employment at several small mines now in production and at others expected to start up will offset these losses.

The industry has made substantial productivity gains by decreasing overhead costs, rationalizing operations and mining higher grade ore. However, the easy gains have been made and extensive research and development will be necessary to maintain the pace of productivity increases. The Mining Association of British Columbia and CANMET are both focusing on this problem with the hiring of mining and mineral processing research coordinators for British Columbia.

Buoyant international demand for coking coal lead to record production for exporting mines. The coal industry received higher prices in U.S. dollars in 1988, but the stronger Canadian dollar will leave the mines in roughly the same relative position as 1987.

The five-year Canada-British Columbia MDA will expire in March 1990. Work in 1988 continued on geoscience projects, environmental impact studies, transportation and infrastructure projects, as well as a number of industrial minerals projects.

THE NORTH

In 1987, the federal government approved a political and economic policy framework which included as an objective "the transfer to the territories of provincial-type responsibilities still held by the federal government". In keeping with this aim, the federal government in 1988 signed an Agreement in Principle for a Northern Accord with each territorial government to negotiate for oil and gas resource management and sharing of oil and gas revenues. Responsibility for mine safety has already been transferred to the Government of the Northwest Territories and will be assumed by the Yukon government in 1989. Transfer discussions are under way in several other areas, including the administration of minerals management.

Yukon Territory

In 1988 the value of mineral production was up 6% to $465 million.

Approximately $50 million was spent on exploration in Yukon and far northern British Columbia, and results from several projects are encouraging. Of note are the Marg polymetallic massive sulphide deposit located northeast of Keno Hill and Cominco Ltd.'s renewed work on the Tom Deposit in the Macmillan Pass area.

A new federal Placer Mining Policy was released in May 1988 under which the Placer Implementation Review Committee set guidelines for suspended solid effluent from placer operations. The guidelines will assist in protecting important fish habitats and will provide the placer mining industry with a formula to ensure more uniform operations.

The Canada-Yukon MDA entered its final year. Results from geochemical surveys sparked industry interest and results from placer research projects pointed the way to improved gold recoveries.

Government and native leaders met in December 1988 and reached agreement on outstanding issues in the Council for Yukon Indians (CYI) land claim. An Agreement in Principle is expected to be signed in 1989. The land selection process for the 41 440 km^2 of land included in the settlement is almost complete and represents about 8% of the Yukon, including 23 530 km^2 to which the CYI will receive both surface and sub-surface title. Native people have expressed concern about the possible environmental impact of new mines. Also, they have requested a moratorium on the staking of mineral lands until the comprehensive land claim is completed. Once selection of land is complete and the agreement finalized, better relations between the industry and the native groups can be expected.

The Klondike Valley Land Use Plan was completed during the year and included the withdrawal of areas near Dawson from placer staking. The Greater Kluane Land Use Planning Commission was established to develop a land use plan for that region. A number of mineral properties are in the area, including the nickel-copper-platinum Wellgreen properties.

Northwest Territories

In 1988, the value of mineral production was up 7.7% to $936 million including $170 million for fuels. Value of metals produced increased 8% as a result of increased value and volume of zinc production. Exploration expenditures, estimated in excess of $70 million for the second year in a row, were predominantly for gold.

Pine Point Mines Limited milled the last of its ore stockpile in the summer of 1988, and is in the process of removing the townsite and rehabilitating the minesite. The loss of the infrastructure that was associated with this mine makes development of any of the small deposits in the area unlikely. Although shipments of Pine Point concentrate will continue for 2 to 3 years, the territory's importance as a lead-zinc producer will be reduced. To compound the problem, with the exception of work in the Slave province and the Sunrise Lake polymetallic deposit, little work is being done in the search for base metals in the Northwest Territories.

Construction is under way at the Colomac 10 000 t/d gold project of Neptune Resources Corp. with production expected in late 1989 or early 1990. This will be the first large tonnage low grade gold operation in the Northwest Territories and if successful could change the standard perception of northern operations. The Kiggivik (Lone Gull) uranium project entered the feasibility study and regulatory approval stage and will be the first northern mining project to go through the Federal Environmental Assessment and Review Process (EARP). The proponent will have to demonstrate that the operation will not damage the environment or the native way of life and will benefit the region before development approval will be given.

Work on the first full year of operation under the Canada-Northwest Territories MDA was carried out in 1988. A total of 31 geoscience mapping projects was conducted under the MDA Geoscience Program and companies are already following up on preliminary results, particularly in the Carp Lake and Hope Bay areas. Two projects were initiated under the Northern Technology Assistance Program (NTAP) which is funded through the MDA and applications are invited for further projects on mining and mineral research. Another MDA initiative, the Northern Public Information Program, assisted the Northwest Territories Chamber of Mines to produce newsletters, posters, displays and other material providing information on mining in the Northwest Territories to suppliers and the general public.

The Dene-Metis Land Claim Agreement in Principle was signed by Prime Minister Mulroney in September 1988. The land selection process is to be completed by 1990. The Dene-Metis will have surface title for a total of 180 000 km^2. Subsurface title will be included on 10 100 km^2 of this area. A Surface Rights Board will be established and will have jurisdiction over matters relating to surface entry and access to private lands. Consultation with the Dene-Metis will be necessary prior to the exercise of a right to develop or produce minerals on all selected lands.

A total of 23 sub-agreements have been initialled for the Tungavut Federation of Nunavut (TFN) land claims agreement and an Agreement in Principle is expected in late 1989.

Work under the Northern Land Use Planning Process is continuing. The Lancaster Sound Land Use Plan, meant to encourage exploration and production while protecting wildlife resources and maximizing the economic benefits, will be completed early in the coming year. The plan covers land use in the northern part of the territory, and indicates areas in which local communities have an interest. It will also minimize adverse impacts from abandonment of work sites. Work has also started on the Beaufort-Mackenzie Delta Land Use Plan. A Land Use Planning Commission has been established and community consultations and workshops are planned.

LEADING MINERALS IN THE PROVINCES, TERRITORIES AND CANADA: 1987 AND 1988

	Value of Production			
	1987[f]	1988[P]	Change 1988/1987	Proportion of Provincial Total
	($ million)		(percent)	
Newfoundland				
Iron ore	660.5	726.6	10.0	81.8
Zinc	9.7	49.3	405.8	5.5
Gold	7.1	x	x	x
Asbestos	19.2	27.1	41.1	3.0
Stone, sand and gravel	25.0	26.0	4.1	2.9
Total	742.8	888.5	19.6	
Prince Edward Island				
Sand and gravel	2.5	2.6	3.3	100.0
Total	2.5	2.6	3.3	
Nova Scotia				
Coal	178.6	207.8	16.3	45.1
Gypsum	53.5	58.2	8.9	12.6
Cement	46.5	58.2	25.3	12.6
Stone, sand and gravel	47.5	56.3	18.5	12.2
Tin	x	x	x	x
Salt	x	x	x	x
Total	406.6	461.1	13.4	
New Brunswick				
Zinc	229.7	379.0	65.0	45.6
Potash	x	x	x	x
Lead	70.3	73.3	4.2	8.8
Silver	56.2	49.9	-11.2	6.0
Coal	33.3	33.9	1.7	4.1
Total	622.2	831.1	33.6	
Quebec				
Gold	562.3	562.9	0.1	20.7
Iron Ore	x	x	x	x
Titanium dioxide	x	x	x	x
Stone	213.1	217.8	2.2	8.0
Iron, remelt	x	x	x	x
Cement	230.0	194.9	-15.3	7.2
Asbestos	171.9	190.3	10.7	7.0
Total	2 780.8	2 716.2	-2.3	
Ontario				
Nickel	869.3	2 166.3	149.2	30.3
Gold	1 007.2	1 002.9	-0.4	14.0
Copper	695.8	824.0	18.4	11.5
Zinc	375.0	548.8	46.4	7.7
Uranium	581.3	523.4	-10.0	7.3
Cement	437.8	449.0	2.6	6.3
Total	5 636.1	7 154.4	26.9	
Manitoba				
Nickel	403.7	1 089.7	169.9	64.8
Copper	160.1	171.2	6.9	10.2
Zinc	81.0	94.2	16.3	5.6
Crude petroleum	109.1	83.1	-23.8	4.9
Gold	70.4	74.2	5.5	4.4
Total	1 000.0	1 680.5	68.0	

LEADING MINERALS IN THE PROVINCES, TERRITORIES AND CANADA: 1987 AND 1988 (continued)

	Value of Production			
	1987^{f}	1988^{p}	Change 1988/1987	Proportion of Provincial Total
	($ million)		(percent)	
Saskatchewan				
Crude petroleum	1 511.5	1 131.6	-25.1	37.2
Potash	x	x	x	x
Uranium	600.9	584.5	-2.7	19.2
Total	3 150.8	3 045.5	-3.3	
Alberta				
Crude petroleum	10 050.3	7 724.2	-23.1	51.8
Natural gas	4 021.7	4 415.2	9.8	29.6
Natural gas by-products	1 809.0	1 559.1	-13.8	10.5
Coal	389.7	456.0	17.0	3.1
Sulphur, elemental	479.4	420.6	-12.3	2.8
Total	17 080.0	14 906.4	-12.7	
British Columbia				
Copper	881.8	1 134.8	28.7	28.4
Coal	947.9	1 100.0	16.1	27.6
Natural gas	366.1	324.4	-11.4	8.1
Crude petroleum	306.0	226.6	-26.0	5.7
Gold	213.6	225.9	5.7	5.7
Total	3 614.0	3 992.1	10.5	
Yukon				
Zinc	187.3	194.9	4.0	41.9
Lead	x	x	x	x
Silver	41.0	84.2	105.5	18.1
Gold	89.0	74.6	-16.2	16.0
Total	437.2	465.5	6.5	
Northwest Territories				
Zinc	328.8	477.6	45.3	51.0
Gold	223.5	197.9	-11.4	21.1
Crude petroleum	144.5	162.6	12.5	17.4
Lead	139.4	67.2	-51.8	7.2
Total	869.3	936.3	7.7	
Canada				
Crude petroleum	12 141.0	9 349.5	-23.0	25.2
Natural gas	4 615.1	4 973.3	7.8	13.4
Nickel	1 273.0	3 256.0	155.8	8.8
Copper	1 923.1	2 317.0	20.5	6.2
Gold	2 204.5	2 215.1	0.5	6.0
Zinc	1 475.2	2 064.6	40.0	5.6
Coal	1 641.3	1 907.8	16.2	5.1
Natural gas by-products	1 876.3	1 609.5	-14.2	4.3
Iron ore	1 395.6	1 388.1	-0.5	3.7
Uranium	1 182.2	1 108.0	-6.3	3.0
Total	36 342.3	37 080.1	2.0	

^{f} Final; ^{p} Preliminary; x Confidential.

Labour and Employment

G. KENDALL

OVERVIEW

In 1988, the Canadian mining industry exhibited strong growth and profitability, and the favourable economic conditions were reflected in the labour market. The rate of growth in employment in the sector was the largest since 1980, and significantly, average wage settlements during the year exceeded the inflation rate. Forecasted direct employment in mining (i.e. Stages I and II excluding oil and gas) for 1988 was 151 775 jobs[1], a decline of 23% from peak levels in 1980, but up 1.9% over 1987.

This chapter includes a closer look at the labour market developments in 1988 for mining, including an overview of the industrial relations scene, plus safety and health highlights. Major legislative developments for the year are also noted.

LABOUR MARKET DEVELOPMENTS

For most commodities, the industry was on the upside of the mineral cycle during 1988. The rate of growth in the sector was an estimated 7.5% and the average return on capital more than doubled from 5% in mid-1986 to 13% in mid-1988. However, the strong financial performance did not translate into an equally dramatic growth in employment.

A closer examination of the data indicates increases in employment for most major commodities, with gold continuing to show the greatest strength. Gold employment was forecast to increase from 9 555 in 1987 to 10 500 in 1988, an increase of nearly 10%. Interestingly, the number of jobs in gold mining as a percentage of all metal mining jobs has increased to 22% from 9% since 1980 (Figure I).

With one exception, employment in metal mines was forecast to increase slightly in 1988 over the previous year. The exception is uranium, where employment levels were forecast to fall, albeit slowly, for the fourth straight year. Total metal mining employment was forecast to be 47 550 in 1988.

Employment in the nonmetals has been virtually flat for three years, evidence of relative stability in these industries. Employment in coal was also stable in overall terms, despite uncertainties in coal markets, and 1988 employment was forecast at 10 900.

Consistent with the strong performance of the economy, and construction in particular, industrial minerals employment continues to show strong growth. Forecast 1988 employment in structural materials, which includes stone quarries, and sand and gravel, was 5900.

Overall, Stage I employment, forecast to be 76 625 in 1988, is increasing slowly (i.e. 2.8% since 1986) after six years of decreases (Figure II). Stage II employment (i.e. primary metals), estimated at 75 150 for 1988, was up 2.8% from 1987, a significant increase but much below the peak employment of 97 000 in 1980 (Figure III).

As Table 1 shows, mining provides employment in all regions of Canada. As of 1986 (the most recent year for which regional employment data are available from the Annual Census of Mines), approximately 33% of employment in Stage I mining was in Ontario, and 19% in Quebec. Sixteen percent of mining employment was in British Columbia, 16% in the Prairie Provinces, and the remainder in the North and Atlantic regions. Stage II employment was more concentrated with 85% located in Ontario and Quebec. The regional distribution continues to be relatively stable.

On the supply side, the pressing issue in 1988 was a shortage of trained labour. While the problem was serious in the skilled trades (e.g. mechanics, electricians), a

---

[1] Stage I is defined as the sum of metal mines, nonmetal mines, structural materials and coal. Stage II is defined as smelting and refining plus iron and steel mills.

G. Kendall, is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 995-1297.

shortage of hard rock miners also emerged. The impact of the shortfall was most acutely felt in certain regions of the country including the Timmins area of Northern Ontario, the Abitibi-Temiscamingue region of Quebec, and the Yukon. One industry estimate is that 2200 new miners will have to be trained in Ontario by the end of 1990 to meet demand.

In response to the shortages, certain mining occupations were selected as eligible under the Government of Canada's Skill Shortages program. The program provides for payments of training costs, wage subsidies and related costs to employers, and payments of relocation costs for qualified individuals. In six provinces and the two territories, hard rock mining was a selected occupation, as was drift mining in Ontario and Manitoba. In Newfoundland, drilling machine and diamond drill operators, as well as scoop tram and trackless mine truck operators, were eligible. In most cases these designations do not expire until late 1989 or 1990.

The number of mine openings in 1988 far outnumbered the closings. Some 35 new mines went into production in 1988, while only four indefinite closures took place.

The indefinite closures in 1988 include (1) the Potash Corporation of Saskatchewan's Cory mine near Saskatoon affecting 200 workers, (2) Noramco Mining Corporation's Golden Rose mine near Thunder Bay involving 100 employees, and (3) TOTAL Energold Corporation's Mount Skukum mine in the Yukon resulting in 98 layoffs. Also the shut down of Cominco Ltd.'s Pine Point mine was completed in March 1988 when the mill was closed affecting some 140 employees. As a result of this closing, the Town of Pine Point, N.W.T. was officially decommissioned during 1988.

Two notable reopenings were announced in 1988. The Bell asbestos mine near Thetford Mines, Quebec, closed in March 1988 for market-related reasons, will return to production in January 1989. Some 365 workers will be recalled. Also, the Gaspé copper mine at Murdochville, Quebec, which was closed in 1987 as a result of a fire, is scheduled to reopen in May 1989. The mine formerly employed some 400 workers, but will employ about 200 when the mine reopens.

COMPENSATION

Average earnings in mining are among the highest of all industrial classifications. For 1987, average weekly earnings for hourly paid and salaried employees combined were $678.84 for metal mines and $595.98 for the nonmetals, in contrast to $519.54 in manufacturing and $539.37 in construction.

Since 1975, real wages in the industry have increased by only 5.4%, in comparison to 3.0% in goods-producing industries as a whole. Most of the real gains occurred in the 1975-81 period, as real compensation fell by 8.2% from 1982 to 1987. For 1987, average annual labour income in the sector was $41 600, still the highest of all major industrial categories. In contrast, average labour income for all industries in 1987 was $27 900, virtually unchanged in real terms from 12 years earlier.

INDUSTRIAL RELATIONS

By historical standards, the number of work stoppages in mining has been low in recent years, and the vast majority of contracts in the industry are signed without a work disruption. The year 1987 witnessed little change from 1986 in the number of stoppages, though for all industries, the number of stoppages, 658, is down over 10%.

In 1987, there were 14 work stoppages in mining; 10 in metals, 1 in nonmetals, 2 in mineral fuels, and one in quarries. There were 8902 workers involved and 228 440 person-days were lost. To place the time lost in context, it represents an estimated 2.0% of the total work time of unionized workers in the sector.

For 1988, while aggregate data are not yet available, there appears to have been an increase in the number of work stoppages. Major strikes/lock-outs involving locals of the United Steelworkers of America (the major union in the sector) took place at Lac Minerals Ltd.'s Bousquet gold mine near Malartic, Quebec in January (one month), Sydney Steel Corporation, (Sysco) Sydney, N.S. (45 days), Lake Asbestos of Québec, Ltd. at Black Lake, Quebec (two and one-half months), Hudson Bay Mining and Smelting Co., Limited's Ruttan mine at Leaf Rapids, Manitoba (over three months), Curragh Resources Inc., at Faro, Yukon (27 days), and Dofasco Inc.'s Sherman and Adams iron ore mines in northeast Ontario (one month). A dispute involving Alcan Smelters and Chemicals Limited in Shawinigan, Quebec and the Federation of Metal Trades which began in October 1987 was settled after five months; and a stoppage which began in May 1988 involving Gibraltar Mines Limited and the Canadian Association of Industrial, Mechanical and Allied Workers was settled on November 28, 1988.

Effective wage increases in mining collective agreements averaged 3.3% in 1987, up from 1.5% in 1986. For the first three quarters of 1988, effective wage increases rose by an average of 5.8%. These increases exceed the average for all industries which was 4.1% in 1987 and 4.3% for the first nine months of 1988. It should be noted that these data exclude non-wage benefits, which can range up to 40% of the value of total compensation.

A preliminary analysis of 1988 collective agreements can reveal trends in mining industry compensation packages. The collective bargaining calendar for 1988 was more active than average, and gave rise to some important settlements. (The July 1988 INCO Limited settlement was seen by some analysts as a possible national trend-setter.) While average wage increases exceeded the rate of inflation for the first time since early in the decade, the specifics of the settlements defied easy generalization. However, it appears that wages are increasingly being linked to profits, productivity, or commodity prices. Another notable development was the prevalence of improved pension provisions, and to a lesser extent better severance provisions. Virtually all settlements are at least two years in duration and the average duration is 2.5 years.

SAFETY AND HEALTH

Mine safety and health continues to be a top priority for workers, governments and the industry itself. Exhaustive efforts are made to prevent injuries and fatalities, and governments in all jurisdictions (federal, provincial and territorial) issue and revise mine safety and health regulations on an ongoing basis.

For 1987 (the most recent year for which complete data is available) evidence indicates qualified improvement in the industry safety record. With respect to injuries, Statistics Canada published data, based on Workers Compensation Board reports, show that there were 4766 time loss injuries in metal and nonmetal mines and quarries in 1987, down from 5024 in 1986. As illustrated in Table 2, this continues a generally downward trend since 1982 when the data were first collected.

The absolute numbers of injuries have limited meaning if not examined in the context of the worker population at risk. A special Statistics Canada study published in the March 1988 "Labour Force Survey" examined this question for the first time. For mines, quarries and oil wells over the 1982-86 period, there were an average of 69 injuries per 1000 persons employed, which is a better record than forestry, construction or manufacturing. As Figure IV illustrates, the trend in injury rates over the period has shown improvement, with injury rates ranging from 73 in 1982 to 60 in 1986.

Published statistics for 1987 indicate that there were 108 fatalities in mining (including quarries and oil wells). Of this number, 58 were the result of occupational injuries sustained during 1987 or earlier years, and 50 were the result of occupational illnesses. An EMR survey of provincial/territorial Chief Inspectors of Mines refines these data somewhat as it focuses on fatalities directly due to mining accidents, and excludes oil and gas. It revealed that there were 44 fatalities as a result of mining accidents in 1987 and 17 during the period January to July 1988.

The fatality frequency rate was 0.6 per thousand workers in 1987, essentially unchanged from 1986. By historical terms, this is low and demonstrates substantial improvement, but rates during the latter part of the 1980s have remained generally flat. Fatality rates in forestry and fishing continue to exceed that of mining.

Mine accidents and the statistics used to monitor them were considered by federal/provincial/territorial Mines Ministers at their 1988 Conference in Quebec City. At the Conference, Chief Inspectors of Mines presented a prototype National Mine Accidents Data Base to Ministers. Ministers expressed support for the project, which should lead to major improvements in the capacity to analyze mine accidents and their causes in Canada. Work is ongoing to secure the participation of all provinces and territories in the project.

LEGISLATIVE HIGHLIGHTS

The federal jurisdiction for labour matters affecting the mining industry is narrowly defined. Responsibility for most labour legislation affecting mining, including safety and health, industrial relations, and conditions of work, rests with the provinces and territories. While there is a broad range of labour legislation across Canada, specific provisions vary widely across the jurisdictions.

Each year, governments enact a wide range of labour legislation that may impact on the mining industry. This section does not attempt to review all such legislation, but rather it outlines developments at the federal level in 1988, with very brief reference to selected provincial initiatives.

Workplace Hazardous Materials Information System (WHMIS)

The regulations under the Workplace Hazardous Materials Information System took effect on October 31, 1988 in the federal and provincial jurisdictions.

Key provisions of WHMIS include (a) establishment of criteria for identifying hazardous materials, (b) a requirement that suppliers and importers ensure that hazardous materials are properly labelled, (c) a requirement that suppliers and importers provide up-to-date information on the hazards of products designated under WHMIS, (d) the provision by employers of requisite training of workers exposed to hazardous substances, and (e) protection of proprietary information. WHMIS represents a major national effort to ensure standards for the protection of workers exposed to hazardous materials.

Over the period of October 31, 1988 to October 31, 1989, a number of transition provisions of WHMIS will be in place. For example, secondary suppliers of controlled products have been given a temporary exemption until March 15, 1989 from certain information and labelling requirements.

Canada Labour Code - Coal Mining Safety

Amendments to Part IV of the Canada Labour Code adopted in July 1988 affect occupational safety and health regulations at the Cape Breton Development Corporation.

The amendments provide for the establishment of a Coal Mining Safety Commission. Comprised of employer and employee representatives, the Commission will have the authority to regulate the use of certain mining methods or equipment for which no prescribed safety standards are in place. It will also have the authority to amend existing safety standards if employee safety is not jeopardized, and to review existing and planned safety procedures.

Other provisions in the amendments include (a) a requirement that the employer permit mine inspections to be conducted on behalf of employees under certain terms and conditions, and (b) authority for searches of persons, including workers, entering the underground portion of the mine site, in order to control the presence of smoking materials, alcohol, or drugs.

Employment Equity

The first Employment Equity Act Annual Report was tabled in Parliament in December 1988. The Act requires federally regulated employers with 100 or more employees to eliminate discriminatory practices, take special measures to achieve a representational workforce, and submit annual reports on their progress. This legislation is scheduled for review in 1991. Data in the 1988 Report show that women were 8% of employees in reporting metal mines, and 3% of employees in reporting coal mines. Among employees of reporting metal mines, 3% identified themselves as aboriginal peoples, 1% as having disabilities, and 1% as members of visible minorities. In reporting coal mines these proportions were 0.2%, 10% and 0.4% respectively.

The majority of mines are subject to provincial employment equity legislation. These laws rely on voluntary programs and on individual complaints against specific discriminatory practices of individual employers in the private sector.

Atomic Energy Control Act - Uranium Mining Regulations

Pursuant to the Atomic Energy Control Act, new regulations were promulgated in April 1988 pertaining to radiation-related safety in uranium and thorium mines. These extensive regulations apply to such areas as licensing, ventilation and dust control, and related safety rules and procedures, and are administered by the Atomic Energy Control Board.

Also in 1988, the Uranium Mines (Ontario) Occupational Health and Safety Regulations were promulgated to permit the application of the Ontario Occupational Health and Safety Act and Regulations to the federally-regulated uranium mines in the area of conventional health and safety.

Provincial Developments

At the provincial level, revisions to labour legislation of note include (a) a major change in Quebec labour relations law which saw the creation of the Commission des relations du travail whose mandate parallels that of labour relations boards existing in other provinces; (b) an overhaul of the Alberta Employment Standards Code and Labour Relations Code; and (c) revisions to the Northwest Territories Labour Standards Act which, among other provisions, reduce the standard work week to 40 hours and increase to 60 hours the maximum weekly hours of work. Also, several provinces introduced increases to the minimum wage, and most jurisdictions revised occupational safety and health legislation and regulations to implement WHMIS.

OUTLOOK

Economic forecasts for 1989 generally project continued solid growth in the Canadian economy, though perhaps at a slower rate than 1988. A slow increase in the rate of inflation and rising interest rates are clouds on the horizon. In most minerals and metals markets, the strong prices seen in 1988 are expected to hold up into 1989. A number of projects under development in 1988 in response to the higher prices will go into production in 1989. Consequently, continued growth in Stage I employment, potentially exceeding the rate of increase in 1988, can be expected.

Average hourly earnings for all industries are projected to increase in the 5% range. Based on settlements in 1988, the rate of increase in wages in mining in the coming year could exceed the national rate.

The collective bargaining calendar for 1989 is relatively quiet, after a busy year in 1988. Major collective agreements (i.e. covering more than 500 employees) expiring in 1989 include Highland Valley Copper at Logan Lake, B.C.; Quintette Coal Limited Tumbler Ridge, B.C.; Fording Coal Limited Elkford, B.C.; BHP-Utah Mines Ltd., Port Hardy, B.C.; and JM Asbestos Inc., Asbestos, Quebec.

At time of writing, only one indefinite closure has been announced for 1989, that being United Keno Hill Mines Limited's silver-lead mine at Elsa, Yukon. Some 170 workers were laid off effective January 1989. In contrast, a preliminary estimate is that over 2900 jobs will be created if all projects announced thus far for 1989 go into production as scheduled.

TABLE 1. CANADIAN MINING INDUSTRY AVERAGE EMPLOYEMENT BY REGION

	1985		1986	
	Employees	Percent	Employees	Percent
STAGE I				
Atlantic	9 578	12	9 642	13
Quebec	15 366	20	14 303	19
Ontario	24 433	32	24 263	33
Prairies	13 198	17	12 168	16
British Columbia	12 169	16	11 558	16
Yukon and Northwest Territories	2 703	3	2 561	3
Canada	77 447	100	74 495	100
STAGE II				
Quebec	22 266	29	21 682	29
Ontario	43 922	56	42 700	56
Other	12 064	15	11 137	15
Canada	78 252	100	75 519	100

Source: Annual Census of Mines, Annual Census of Manufactures.

TABLE 2. NUMBER OF TIME-LOSS INJURIES, MINING, 1982-87

	Mines, Quarries and Oil Wells	Metal and Nonmetal Mines	Mineral Fuels
	(SIC 051-099)	(051-059, 071-079)	(061-064)
1982	12 425	5 603	3 541
1983	11 717	5 114	3 153
1984	12 322	5 595	2 286
1985	13 471	5 411	3 175
1986	11 105	5 024	2 191
1987	11 103	4 766	1 931

Source: Statistics Canada.

Figure I

SELECTED MINERAL COMMODITIES

EMPLOYMENT, STAGE 1: MINING

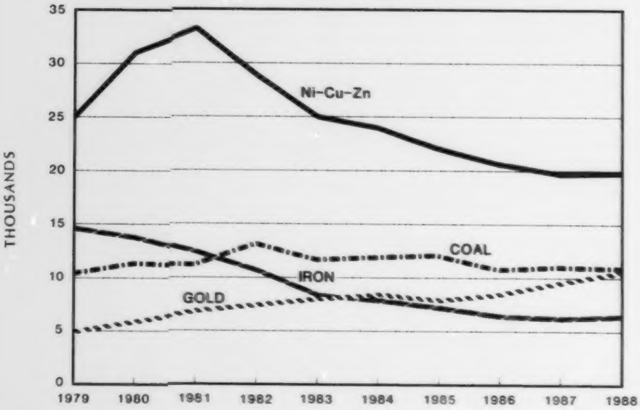


Figure II

MINING AND PRIMARY METALS

EMPLOYMENT, STAGE 1 AND 2

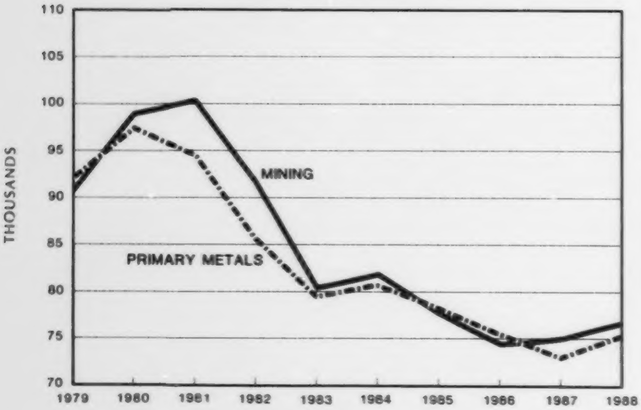


Figure III

MINING EMPLOYMENT

TOTALS: STAGE 1

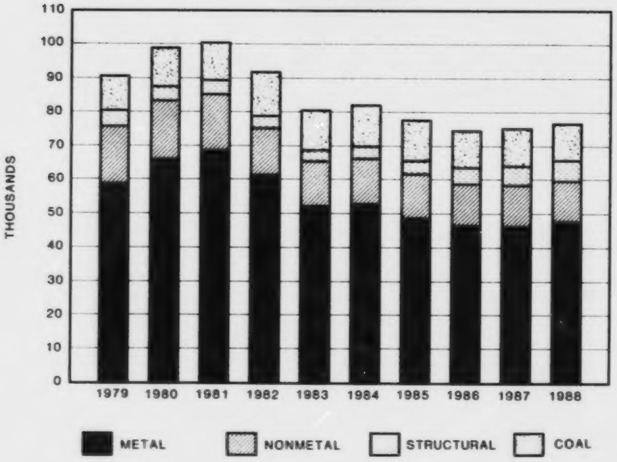
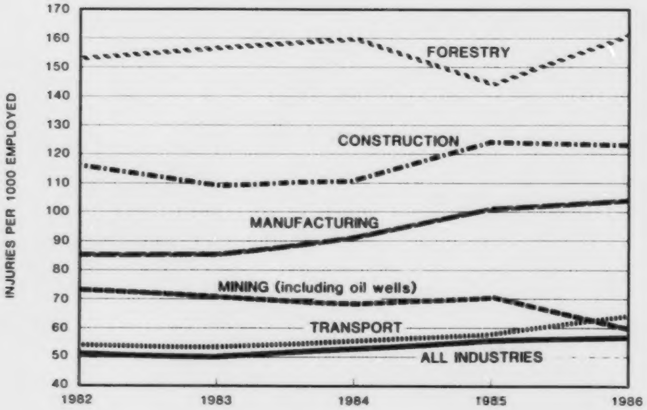


Figure IV

TIME-LOSS INJURY RATES BY INDUSTRY

CANADA, 1982-86



Summary of Canadian Ore Reserves

(Data available in 1988)

J. ZWARTENDYK

Any assessment of future supply of a given mineral commodity from Canadian mines requires information on current working inventories, i.e., on the amounts of ore known to be present in operating mines and on additional known tonnages in deposits that are close to being profitably mineable. The tonnages that - in 1988 - were fairly well delineated and judged to be mineable are reported below as "reserves" (Figure 1). The limits of what is included in reserves are further specified in each case.

		1988
(A)	**Copper**	12 939 Kt
	Nickel	6 605 Kt
	Lead	6 694 Kt
	Zinc	20 636 Kt
	Molybdenum	221 Kt
	Silver	26 Kt
	Gold	1 727 t

The quantities of the metals listed above are contained in ore recoverable from current mines (including those "temporarily" closed) and from deposits that had been committed for production up to January 1, 1988.

These quantities represent proven and probable tonnages; any additional "possible" tonnages are not included.

(B) Iron 1 400 Mt

This is the approximate quantity of iron contained in known crude ore in producing mines. Ore in undeveloped deposits is not included.

(C) Asbestos 40 Mt

This represents the fibre content (on average, about 5.4%) of 739 Mt of mineable ore reserves in producing mines.

(D) Potash 14 000 Mt (K_2O equivalent), corresponding to 23 000 Mt KCl product (standard fertilizer - exported product)

This amount would be recoverable by conventional mining (to a depth of about 1 100 m) from known potash deposits. At least an additional 42 000 Mt (K_2O equivalent) would be recoverable from known deposits by solution mining at depths beyond 1 100 m; this would represent 69 000 Mt of KCl product.

J. Zwartendyk is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone: (613) 996-1611.

(E) Uranium

	"Reasonably Assured"	
	Proven (Measured)	Probable (Indicated)
	(tU)	
Recoverable from mineable ore, at uranium prices of:		
C$100/kg U or less:	44 000	104 000
$100 to $150/kg U:	1 000	94 000

The tonnages refer to uranium recoverable from mineable ore[1]. Unless otherwise specified, uranium "reserves" in Canada refer to the tonnages mineable at uranium prices in the low range only.

(F) Coal

- **Bituminous** 3 471 Mt (of which 1 918 Mt could be used for metallurgical purposes)
- **Subbituminous** 871 Mt
- **Lignitic** 2 236 Mt

These represent tonnages that could be profitably recovered as raw coal, given current technology and economics, from measured (proven) and indicated (probable) coal in deposits that are legally open to mining. For the purpose of making these estimates, it was assumed that coal sales would cover the costs of any required infrastructure not already in place[2].

THE FLOW FROM RESOURCES TO RESERVES TO MINERAL SUPPLY

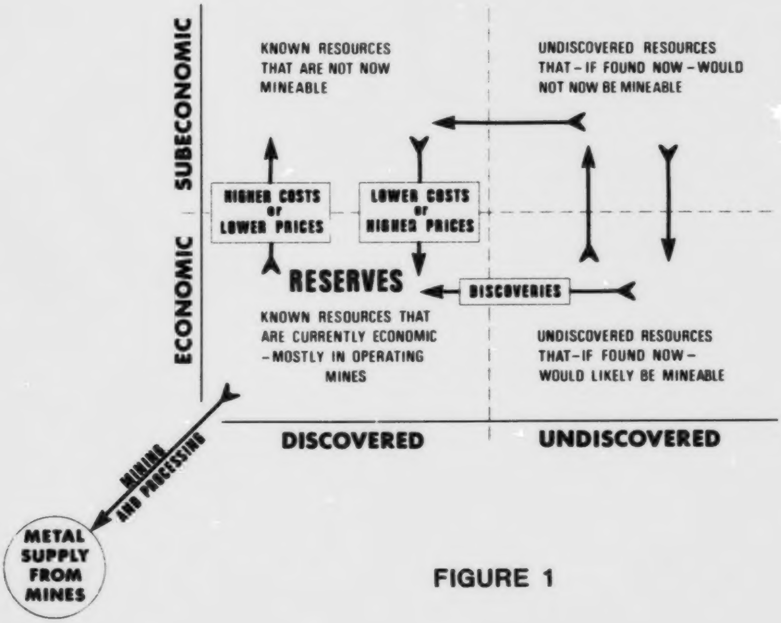

SUBECONOMIC
ECONOMIC
KNOWN RESOURCES THAT ARE NOT NOW MINEABLE
UNDISCOVERED RESOURCES THAT - IF FOUND NOW - WOULD NOT NOW BE MINEABLE
HIGHER COSTS or LOWER PRICES
LOWER COSTS or HIGHER PRICES
RESERVES
DISCOVERIES
KNOWN RESOURCES THAT ARE CURRENTLY ECONOMIC - MOSTLY IN OPERATING MINES
UNDISCOVERED RESOURCES THAT - IF FOUND NOW - WOULD LIKELY BE MINEABLE
DISCOVERED
UNDISCOVERED
MINING AND PROCESSING
METAL SUPPLY FROM MINES

FIGURE 1

---

[1] September 1988, Energy, Mines and Resources Canada.

[2] CANMET Report 87-3E, "Coal Mining in Canada: 1986", Energy, Mines and Resources Canada, 1987.

Canadian Mine Reserves, Development and Promising Deposits

A. LEMIEUX

RESERVES

Table 1 illustrates the annually changing levels of Canadian reserves of seven major metals, in terms of the metal content of ore. These quantities were computed on the basis of information provided by mining companies. They pertain to ore tonnages that, as far as could be determined, were known at a level of assurance equivalent to "proven" and/or "probable". Tonnages reported as "possible" were not included. Table 2 shows a province-by-province breakdown for reserves as at January 1, 1988.

While the term "reserves" is widely used to refer to that part of mineral resources that, on a given date, is well delineated and considered economically mineable, the reserves in Table 1 and Table 2 are confined to those in producing mines and in deposits that have been committed for production. These reserve data constitute the reliable core of information. For other deposits, where concrete steps have not been taken by companies to prepare them for mining, judgments by outsiders regarding economic mineability would not form a consistent basis for reporting reserves. The purpose of the "reserves" restrictions used here is to avoid such subjective judgments.

The quantities of reserves reported cannot, by themselves, give any indication of whether or not Canada might be running out of economically mineable minerals. Future production will draw not only on the 1988 reserves but also on additional reserves yet to be developed -- from discoveries, from extensions to known orebodies and from known but currently marginal or uneconomic material. EMR's annual mineral bulletin[1] on Canadian mines deals with Canadian capability for metal production both from operating mines and from known deposits for which future production can be considered likely.

Total national reserves of the seven nonferrous metals saw their last concerted rise in the 1979-81 period. Gold reserves have kept on rising, but reserves of the other metals have steadily declined since 1981-82. Compared with 1981, reserves in 1988 were down 23% for copper, 20% for nickel, 34% for lead, 30% for zinc, 60% for molybdenum, and 24% for silver. For gold, however, reserves were up 124%. During 1987 alone, the downward trend continued for all these metals except gold, for which the reserves kept rising.

Mine by mine and province by province, there continued to be considerable departures from national trends. Reserves in most mines change slightly from year to year, but on balance these changes cancel out in national totals. It is the relatively few mines with large changes that affect the overall direction of national trends.

Gold

From 1987 to 1988, Canadian reserves of gold in mineable ore increased more than 15% because of new operations and new commitments to produce gold i) from conventional gold mines, ii) from tailings and other gold-bearing wastes left behind by previous mining operations, and iii) as a by-product mainly from base-metal mines (Table 3).

Tailings and other gold-bearing wastes from past mining operations are increasingly contributing to Canadian gold reserves. The largest single addition to gold reserves during 1987 was ERG Resources Inc.'s tailings reprocessing project in Timmins, Ontario, accounting for more than 60 t of new gold reserves, about half of which is expected to be recovered in mine bullion over a period of 15-20 years. Gold in all types of mine wastes accounted for about one third of the new mineable reserves added to the Canadian total during 1987.

Of the total Canadian mineable reserves of gold, 78% occurs in conventional gold mines, 16% in mines where gold is produced as a by-product, and the remaining 6% in

---

[1] A. Lemieux, L.-S. Jen, G. Bouchard and D.A. Cranstone, "Canadian Mines: Perspective From 1988," Energy, Mines and Resources Canada, Ottawa.

A. Lemieux, is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 992-2709.

tailings and other gold-bearing rock waste that will be reprocessed (Table 4). More than 90% of the gold contained in ores produced from conventional gold mines is recovered in concentrator products. Base-metal ores with minor gold content as well as old gold-mining wastes yield only about half of their gold content. Overall, more than 80% of the gold now counted in Canadian reserves is expected to be recovered in concentrator products in the course of mining and processing.

Molybdenum

Molybdenum reserves fell by more than 35% from 1987 to 1988. The permanent closure during 1987 of Amax of Canada Limited's Kitsault mine, located at Alice Arm in British Columbia, reduced molybdenum reserves by some 119 000 t, accounting for virtually all of this decline. Production at the Kitsault mine had been suspended since 1982.

Brenda Mines Ltd. a producer of molybdenum in British Columbia, carried out research during 1987 on columnar flotation as a means of recovering by-product molybdenum from Hemlo Gold Mines Inc.'s Golden Giant mine in Ontario. A decision on production of molybdenum at the Golden Giant mine is yet to be made.

Zinc

Zinc reserves were down 8% from 1987 to 1988. Only about a third of the zinc mined during 1987 was replaced with new reserves. The single largest decrease took place at Cominco Ltd.'s Polaris mine in the Northwest Territories where reserves were revised downward because the company foresees leaving more zinc in mine pillars than was previously expected.

Lead

As in the case of zinc, new reserves did not make up for ore mined during 1987. This, combined with the downward reassessment of reserves at the Polaris mine, led to most of the 7% drop in lead reserves from 1987 to 1988. No mines reported significant net additions to lead reserves during 1987.

At Cominco's Sullivan mine in British Columbia, the concentrator is being modified to begin processing low-grade material along with the ore normally processed. Over the next few years, this will augment the mine's lead reserves, but it remains to be seen by how much.

Copper

The largest single gross addition to copper reserves took place at Placer Dome Inc.'s Gibraltar mine in British Columbia as a result of higher copper prices. The previous year, reserves had been reduced because of lower price expectations. Minnova Inc.'s Ansil mine in Quebec, committed for production during 1987, also gave a substantial boost to Canadian copper reserves.

On balance, however, reserves declined about 3% during 1987 because gross additions to reserves did not fully replace ore mined, because reserves were apparently written down at some mines, and because we stopped counting as reserves copper in certain deposits that now appear unlikely to be mined in the foreseeable future.

Silver

Reserves of silver were down about 4%, largely because only about half of the 1987 production was replaced with newly-developed ore and because a number of mines apparently wrote down some of their silver reserves. Cheni Gold Mines Inc.'s Lawyers mine, located in the Toodoggone area of north-central British Columbia, which was committed for production during 1987, provided the only outstanding gross addition to silver reserves from 1987 to 1988.

Nickel

About a fourth of the nickel mined during 1987 was apparently replaced by new reserves. The nickel in two new mines committed for production during 1987 was added to total Canadian reserves for 1988: Namew Lake near Flin Flon in Manitoba, owned jointly by Hudson Bay Mining and Smelting Co., Limited (HBMS) and Outokumpu Mines Ltd., which is expected to become one of the lowest-cost nickel mines in the western world; and Lac des Isles near Thunder Bay in Ontario, where nickel will be produced along with gold and copper as by-products of platinum-group metal mining. Overall, nickel reserves declined about 1.5%. Nickel reserves are still much larger relative to production levels than are the reserves of the other base metals.

DEVELOPMENT

During 1987, mining and exploration companies invested some $5 billion in total in Canada. This covers all metals, nonmetals, construction materials, and coal; it excludes oil and gas.

Expenditures on exploration have been in the limelight since 1983 when flow-through shares became widely used as a mechanism for financing the search for new mineral deposits, especially gold. But even at the record level of some $1.3 billion in exploration expenditures in 1987, this still amounts to only one quarter of all investments made by mining and exploration companies combined. Production-related mine site investments (as opposed to exploration investments) amounted to some $3.6 billion in 1987.

Highlights of 1987

Of the $3.6 billion of production-related investments at mine sites in 1987 in Canada, 43% went into repairs (uncapitalized) of existing structures, machinery and equipment; 31% into outlining and preparing ore for production; 16% into installing new machinery and equipment; and 10% into constructing new buildings, underground installations, and tailings ponds.

Not surprisingly, almost 70% of these expenditures were made at mines located in Ontario, British Columbia, and Quebec, by far the country's leading producers (in that order) of the minerals under discussion (Figure 1).

Metal producers accounted for more than 60% of the total investments, gold producers alone for more than 20%. Among nonmetal producers, coal producers invested the most (Figure 2).

Investment Trends

All minerals. Since 1981, overall production-related investments at Canadian mine sites (in constant dollars) have declined almost 40% (Figure 3). Annual expenditures to maintain buildings, machinery and equipment in running order have levelled off; 1987 expenditures on new buildings and new machinery and equipment alone were roughly half of what they were in the early 1980s[1].

Nonmetallic. Annual production-related mine site investments in nonmetallic production, which also includes coal, quarried stone, sand and gravel, have been steadily falling, down some 45% in 1987 from the $2.3 billion peak (in 1987 dollars) of 1982.

Metallic (except gold). Mine site investments in metallic minerals except gold has also been on the decline over the same period. Investments in these metals peaked in 1980, fell by almost 50% to 1983, and slowly declined since then.

Except for a slight rise in 1984-85, investments in base-metal production have been essentially flat since 1983, the earliest year for which disaggregated data are available for base metals.

Gold. Mine site investments in gold have risen more than threefold from $260 million (in 1987 dollars) in 1981 to more than $800 million in 1987, as many new gold discoveries have been put into production and as production capacity at some existing mines has been upgraded.

New Projects Announced During 1988

New projects announced during 1988 to bring on-stream, during the next few years, additional capability for ore and concentrate production in Canada will require expenditures of more than $750 million; half of this was budgeted for precious-metal projects, almost all gold (Table 5). This was about the same as the amount announced during 1987. At least 25 new deposits were committed for production during 1988, about 70% of the unusually large number committed during 1987 which reflected the results of record high exploration activity. At least 17 of the 25 new commitments in 1988 are for gold projects.

PROMISING DEPOSITS

The number of additional deposits judged on the basis of tonnage, grade, cumulative exploration and development effort, and infrastructure, to be promising for production in the foreseeable future (Table 6) has grown each year for the past decade. Since 1977, that number has more than doubled to some 160. The balance has swung toward gold: in 1977, only one promising deposit out of ten was a gold deposit; in 1988, nine out of ten are gold deposits.

OUTLOOK

The next few years should see a stream of further production decisions, primarily on gold deposits, which will raise Canadian gold reserves even higher. Ongoing exploration is expected to lead to the recognition during

---

[1] The future needs of mine site investment in Canada are discussed in: Lemieux, A.; "Production-Sustaining Investment at Mine Sites", Canadian Mineral Industry Monthly Report, Energy, Mines and Resources Canada, November 1988.

1989 that an additional sizeable number of gold deposits may be developed into producing mines.

Reserves of base metals, which have been steadily declining for six or seven years, are likely to decline further in the coming years. As early as 1989, mine site investments in base-metal production may be eclipsed by investments to maintain gold production, something that probably last occurred in the 1930s, during the heyday of gold mining in Canada.

Reserves of copper, zinc and lead have fallen to such low levels that, unless annual mineral discovery rates soon return to the all-time highs of the post-war period, Canada will not be able to maintain its share of world markets for these metals after the mid-1990s[1]. The lack of growth in total mine site investments in base metals from 1983 to 1987 illustrates even more dramatically the challenge that must be met if Canada is to maintain its base-metal production beyond the middle of the next decade.

To meet the challenge and find enough deposits to take over from those nearing exhaustion, it will be necessary to keep annual exploration spending in Canada at least at the 1987 record level, i.e., $1.3 billion, for the foreseeable future - - and emphasize base metals.

But that is only the first step. Annual mine site investments may have to be some 4 times as large as exploration spending, perhaps $5-6 billion, to produce from newly found deposits at the levels required for Canada to hold on to its share of world markets.

---

[1] See, for example, Cranstone, D.A., and Lemieux, A., "Base Metals - Today's Exploration Challenge", Congrès Annuel de l'Association des Prospecteurs du Québec, Val-d'Or, Quebec, September, 1988.

TABLE 1

CANADIAN RESERVES, 1978–88

Quantities of Metals Contained in Proven and Probable Mineable Ore[1]
In Operating Mines and Deposits Committed for Production as at January 1st

Metal	Units[2]	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988[4]
Copper	000 t	16 471	15 840	16 405	16 831	15 815	17 022	16 163	15 788	14 384	13 331	12 939
Nickel	000 t	7 389	7 070	7 245	8 304	8 013	7 581	7 339	7 222	7 047	6 704	6 605
Lead	000 t	8 934	8 911	9 557	10 119	10 244	9 029	9 048	8 887	8 012	7 167	6 694
Zinc	000 t	26 908	26 452	28 635	29 436	29 505	26 077	26 371	26 218	23 747	22 423	20 636
Molybdenum	000 t	384	462	554	550	514	494	446	392	363	346	221
Silver	t	29 085	29 398	31 564	33 614	32 154	31 381	31 359	31 298	28 795	26 694	25 648
Gold[3]	t	366	410	540	770	842	838	1 167	1 205	1 358	1 496	1 727

[1] No allowance is made for losses in milling, smelting and refining. [2] One tonne = 1.1023113 short tons. One kilogram = 32.150746 troy ounces. [3] Excludes metal in placer deposits. [4] Includes metal in mines where production has been suspended indefinitely.

TABLE 2

CANADIAN RESERVES BY PROVINCE

Quantities of Metals Contained in Proven and Probable Mineable Ore[1]
In Operating Mines and Deposits Committed for Production as at January 1, 1988[2]

Metal	Units[3]	Nfld.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	B.C.	Y.T.	N.W.T.	Canada[5]
Copper	000 t	-	62	311	806	6 103	475	5	5 177	-	-	12 939
Nickel	000 t	-	-	-	-	4 822	1 784	-	-	-	-	6 605
Lead	000 t	-	-	3 551	-	104	25	0	1 180	1 212	621	6 694
Zinc	000 t	95	104	8 736	897	3 454	612	1	2 435	1 765	2 538	20 636
Molybdenum	000 t	-	-	-	0	19	-	-	202	-	-	221
Silver	t	-	-	9 699	1 501	6 057	729	2	5 621	1 896	143	25 648
Gold[4]	kg	41 145	-	59 272	297 355	997 747	58 484	1 264	167 419	13 328	90 638	1 726 653

[1] No allowance is made for losses in milling, smelting and refining. [2] Includes metal in mines where production has been suspended indefinitely. [3] One tonne = 1.1023113 short tons. One kilogram = 32.150746 troy ounces. [4] Excludes metal in placer deposits. [5] May not balance due to rounding at the provincial level.
- Nil.

TABLE 3. NEW MINING OPERATIONS AND COMMITMENTS TO PRODUCTION THAT RAISED TOTAL CANADIAN GOLD RESERVES DURING 1987

Operation	Companies	Province
Mobrun	Audrey Resources Inc.	Que.
Joe Mann	Campbell Resources Inc.	Que.
Beacon II	D'Or Val Mines Ltd. (now Amalgamated d'Or Val Perron Mines Ltd.)	Que.
Golden Pond East	INCO Gold Company and Golden Knight Resources Inc.	Que
Bousquet II	Lac Minerals Ltd.	Que.
Orion	Malartic Hygrade Gold Mines (Canada) Ltd.	Que.
Beardmore rock dumps	Ateba Mines Ltd.	Ont.
Omega	Belmoral Mines Ltd.	Ont.
Whitney	Belmoral Mines Ltd. and Broulan Resources Inc.	Ont.
Kremzar	Canamax Resources Inc.	Ont.
Kirkland Lake–Toburn tailings	Eastmaque Gold Mines Ltd.	Ont.
Golden Rose	Emerald Lake Resources Inc.	Ont.
	(now Noramco Mining Corporation)	Ont.
Timmins tailings	ERG Resources Inc.	
Tisdale	Getty Resources Limited (now TOTAL Energold Corporation) and Davidson Tisdale Mines Limited	Ont.
Delnite	Giant Yellowknife Mines Limited	Ont.
Lake Shore tailings	Lac Minerals Ltd.	Ont.
Tyranite tailings	Mill City Gold Inc. and Tyranex Gold Inc.	Ont.
Scadding	Orofino Resources Limited	Ont.
Dona Lake	Placer Dome Inc.	Ont.
Stock	St. Andrew Goldfields Ltd.	Ont.
Golden Patricia	St. Joe Canada Inc. (now Bond Gold Canada Inc.)	Ont.
Tartan Lake	Granges Exploration Ltd. and Abermin Corporation	Man.
Puffy Lake	Pioneer Metals Corporation	Man.
Lawyers	Cheni Gold Mines Inc.	B.C.
Golden Bear	Chevron Minerals Ltd. and North American Metals Corp.	B.C.
O.B.	Skylark Resources Ltd. and Viscount Resources Ltd.	B.C.
Johnny Mountain	Skyline Explorations Ltd.	B.C.
Union tailings	Sumac Ventures Inc.	B.C.
Giant tailings	Giant Yellowknife Mines Limited	N.W.T.
Ptarmigan	Treminco Resources Ltd.	N.W.T.

Source: EMR.

TABLE 4. CANADIAN RESERVES OF GOLD: SOURCES AND RECOVERABILITY

Sources	Gold in Mineable Reserves		Expected Concentrator Recovery	Gold Recoverable in Concentrates	
	(t)	(%)	(%)	(t)	(%)
Conventional Gold Mines	1 352	78	93	1 254	87
By-product Gold (in base-metal deposits)	277	16	49	136	10
Tailings and Other Wastes	98	6	50	49	3
Total	1 727	100	83	1 439	100

Source: EMR.

TABLE 5. MINE AND CONCENTRATOR PROJECTS ANNOUNCED DURING 1988

Company	Project	Metal	Start-up Year	Incremental Project Budget ($ million)
PRECIOUS METALS				
Neptune Resources Corp., Johnsby Mines Limited	New open pit Colomac mine and 9 000 t/d concentrator, Indin Lake, Northwest Territories	Gold	1989	135.
Westmin Resources Limited, Pioneer Metals Corporation, Canacord Resources Inc.	New open pit Premier mine and 2 000 t/d concentrator, Stewart area, British Columbia	Gold, silver	1989	88.
Minnova Inc., Rea Gold Corporation	New Samatosum open pit/underground mine and 450 t/d concentrator, Adams Lake, British Columbia	Silver, lead, zinc, copper, gold	1989	32.2
Muscocho Explorations Ltd., Flanagan McAdam Resources Inc., Windarra Minerals Ltd	New Magnacon underground mine and 550 t/d concentrator, Wawa area, Ontario	Gold	1989	29.
Augmitto Explorations Limited	New Beauchastel underground mine and 900 t/d concentrator, Rouyn, Quebec	Gold	1989	20.8
Corona Corporation, International Mahogany Corp	New Jolu underground mine and 400 t/d concentrator, La Ronge area, Saskatchewan	Gold	1988	20.
Cambior inc.	New 390 000 t/y Pascalis underground mine and pre-concentrator, Val-d'Or area, Quebec	Gold	1989	15.5
Louvem Mines Inc.	Deepening of Chimo mine shaft, Val-d'Or area, Quebec	Gold	1989	8.7
Rouyn Mining Resources Inc., Lac Minerals Ltd.	New 450 t/y Francoeur underground mine, Rouyn area, Quebec	Gold	1988	8.5
Aur Resources Inc.	New 66 000 t/y Kierens (First Canadian) underground mine, Val-d'Or, Quebec	Gold	1988	8.2
Candorado Mines Ltd., Cantrell Resources Ltd.	New 3 600 t/d Hedley tailings leaching pad, Hedley, British Columbia	Gold, silver	1988	3.2
Treminco Resources Ltd.	New 180 t/d concentrator, Yellowknife area, Northwest Territories	Gold	1989	1.2

New Privateer Mine Limited	Reactivation of the Privateer mine and construction of 90 t/d concentrator, Zeballos area, Vancouver Island, British Columbia	Gold	1988	1.
Cambior inc.	New 250 000 t/y Pierre Beauchemin (Eldrich-Flavel) underground mine, Rouyn area, Quebec	Gold	1988	n.a
Aurizon Mines Ltd.	New Sleeping Giant (Soisson) underground mine and 900 t/d concentrator, Amos area, Quebec	Gold, silver	1988	n.a.
Muscocho Explorations Ltd., McNellen Resources, Inc.	New Magino underground mine and 360 t/d concentrator, Wawa area, Ontario	Gold	1988	n.a.
Pelham Gold "N" Grain Inc., Cumo Resources Ltd.	New Louanna tailings reprocessing operation, Nakina, Ontario	Gold	1989?	n.a.
			Subtotal	371.
OTHER METALS				
INCO Limited	Reactivation of Birchtree underground mine and new Thompson South open pit mine, Thompson, Manitoba	Nickel, copper, precious metals	1989-90	100.
	Consolidation of ore concentrating operations, Sudbury area, Ontario	Nickel, copper, precious metals	1991	89.
Highland Valley Copper	Relocation of Highmont Mining Corporation concentrator to Lornex Mining Corporation Ltd. concentrator site, and increase in concentrator capacity to 131 000 t/d, Highland Valley mine, Kamloops area, British Columbia	Copper, molybdenum	1989	70.
East West Caribou Mining Limited	Reactivation of Caribou mine and construction of 2 000 t/d concentrator, Bathurst, New Brunswick	Zinc, lead, silver, gold	1988	55.
Noranda Minerals Inc.	Reopening of underground operations, Murdochville, Quebec	Copper, silver	1989	20.
Hudson Bay Mining and Smelting Co., Limited, (HBMS) Manitoba Mineral Resources Ltd.	New 450 000 t/y Callinan underground mine, Flin Flon area, Manitoba	Zinc, copper, silver, gold	1989	18.
Hudson Bay Mining and Smelting Co., Limited	New 1 000 t/d Chisel Lake open pit mine (crown pillar), Snow Lake area, Manitoba	Zinc, copper, lead, silver, gold	1988	18.
Teck Corporation, Cominco Ltd., Imperial Metals Corporation	New open pit Ajax mine, Kamloops area, British Columbia	Copper, gold	1989	12.

TABLE 5 (cont'd)

Company	Project	Metal	Start-up Year	Incremental Project Budget ($ million)
Curragh Resources Inc.	New Grum open pit mine, Faro area, Yukon	Zinc, lead, precious metals	1990	n.a.
	New Vangorda open pit mine, Faro area, Yukon	Zinc, lead, precious metals	1989	n.a.
Savoy Minerals Ltd.	New Pilot Bay mine, Nelson area, British Columbia	Zinc, lead, silver	1988	n.a.
Teck Corporation, Comet Industries Ltd., Davenport Industries Ltd., Initial Developers Limited	New Comet-Davenport open pit mine, Kamloops, British Columbia	Copper	1988	n.a.
			Subtotal	382
			Grand Total	753

Source: EMR.
n.a.: Not available.

TABLE 6

TONNAGES AND GRADES OF ADDITIONAL DEPOSITS CONSIDERED IN LATE 1988 MOST PROMISING FOR FUTURE PRODUCTION

1. DEPOSITS: Individual deposits have been selected primarily on the basis of information contained in current public reports with respect to (a) state of exploration and development, (b) tonnage and grade, (c) available infrastructure, and (d) mining method and other factors affecting viability. This list includes mostly deposits for which recent exploration and development activities have been publicly reported.
2. TONNAGE and GRADE: As reported by companies or, where necessary, from the secondary source that appeared to be the best informed. Imperial units reported were converted to metric units and rounded. Descriptions such as "probable and possible" are those reported by companies.
3. Where two or more companies are identified with a deposit, the first is usually the operator

COMPANY AND DEPOSIT	TONNAGE	GRADE						
		Cu	Ni	Pb	Zn	Mo	Ag	Au
	tonnes[1]	%	%	%	%	%	g/t	g/t
NEWFOUNDLAND								
Dolphin Explorations Ltd.								
Corona Corporation								
Cape Ray – probable and possible	1 032 000	-	-	-	-	-	-	9.6
Noranda Exploration Company, Limited								
BP Resources Canada Limited								
Duck Pond – geological	4 030 000	3.5	-	1.1	6.6	-	67.4	1.0
NOVA SCOTIA								
Acadia Mineral Ventures Limited								
Mooseland – probable, possible and potential	1 066 000	-	-	-	-	-	-	16.
Exploration Orex Inc.								
Onitap Resources Inc.								
Goldboro – probable	1 270 000	-	-	-	-	-	-	6.9
Gunnar Gold Inc.								
Mill City Gold Inc.								
Greenstrike Gold Corp.								
Petromet Resources Limited								
Pan East Resources Inc.								
Fifteen Mile Stream – drill indicated probable	245 015	-	-	-	-	-	-	9.6
Murray Brook Resources Incorporated								
Cochrane Hill – geological proven, probable and possible	609 925	-	-	-	-	-	-	11.0
Westminer Canada Limited								
Moose River (Touquoy) – in situ geological	1 100 000	-	-	-	-	-	-	2.4
Oldham & Montague (tailings) – mineable proven and probable	339 000	-	-	-	-	-	-	1.66
NEW BRUNSWICK								
Corona Corporation								
M.E.X. Explorations Ltd.								
Elmtree Brook	408 000	-	-	-	-	-	-	4.8

Table 6. (cont'd)

COMPANY AND DEPOSIT	TONNAGE	GRADE						
		Cu	Ni	Pb	Zn	Mo	Ag	Au
	tonnes[1]	%	%	%	%	%	g/t	g/t
Noranda Exploration Company, Limited								
Canacord Resources Inc.								
Conwest Exploration Company Limited								
Half Mile Lake	12 300 000	0.19	-	2.52	7.50	-	31.	-
NovaGold Resources Incorporated								
Murray Brook (Gossan) – probable mineable	1 533 000	-	-	-	-	-	51.1	1.3
QUEBEC								
Abitibi Metal Mines Ltd.								
Jolin	210 000	-	-	-	-	-	-	6.00
Augmitto Explorations Limited								
St. Genevieve Resources Ltd.								
Gold Vessel Resources Inc.								
Parbec (Malartic) – possible	413 000	-	-	-	-	-	-	4.63
Aunore Resources Inc.								
Nova Beaucage Mines Limited								
Elder (No. 1 vein) – proven, probable, possible and geological	998 926	-	-	-	-	-	-	5.8
Elder (No. 3,4,5 veins) – probable and possible	1 299 749	-	-	-	-	-	-	5.42
Aur Resources Inc.								
Orenada (Bourlamaque) Zone 4	671 000	-	-	-	-	-	-	5.5
Aur Resources Inc.								
Nova-Cogesco Resources Inc.								
Nolartic (Vassan) Main Zone – drill indicated	780 000	-	-	-	-	-	-	4.46
Aurizon Mines Ltd.								
Louvem Mines Inc.								
Pascalis-Nord (Pascalis)	233 500	-	-	-	-	-	-	6.8
Belmoral Mines Ltd.								
Wrightbar Mines Ltd.								
Wrightbar (Bourlamaque)	299 000	-	-	-	-	-	-	7.5
Belmoral Mines Ltd.								
Yorbeau Resources Inc.								
ERG Resources Inc.								
Astoria (Rouyn) – proven, probable and possible	1 271 503	-	-	-	-	-	-	6.14
Bitech Energy Resources Limited								
Greenstone Resources Ltd.								
Tache – geological	1 433 000	-	-	-	3.31	-	-	1.89
Cambior inc.								
Mouska – probable and possible	1 450 000	-	-	-	-	-	-	6.2
Rouyn-Merger – probable and possible	466 300	-	-	-	-	-	-	6.1

Cambior inc.								
Bachelor Lake Gold Mines Inc.								
Flordin (Desjardins) – indicated	527 769	–	–	–	–	–	–	5.0
Dundee – Palliser Resources Inc.								
North American Rare Metals Limited								
Vezza – possible	2 030 000	–	–	–	–	–	–	5.1
Exploration Essor Inc.								
Black Cliff Mines Limited								
Abior (Malartic) –drill indicated	210 000	–	–	–	–	–	–	7.5
Goldex Mines Limited								
Goldex (Dubuisson) – probable	777 000	–	–	–	–	–	–	7.2
INCO Gold Company								
Golden Knight Resources Inc.								
Golden Pond Main	4 191 000e	–	–	–	–	–	–	7.9e
Golden Pond West	3 824 000	–	–	–	–	–	–	6.5
INCO Gold Company								
Société d'Exploration Minière Vior Inc.								
Cambior inc.								
Douay Vezza – drill indicated geological	505 000	–	–	–	–	–	–	7.9
Jonpol Explorations Limited								
Dalquier – drill indicated	739 000	1.00	–	–	3.5	–	103.	0.3
Louvem Mines Inc.								
Monique Exploration Inc.								
Courvan Mining Company Limited								
Courvan (Louvicourt) – probable	216 900	–	–	–	–	–	–	7.2
McAdam Resources Inc.								
Tashota-Nipigon Mines Limited								
Konteko Resources Inc.								
Clerno – drill indicated and possible	221 850	–	–	–	–	–	–	3.77
McWatters	826 326	–	–	–	–	–	–	6.5
Minnova Inc.								
Syngold Exploration Inc.								
Donalda – drill indicated	729 000	–	–	–	–	–	–	8.6
Monique Exploration Inc.								
Louvem Mines Inc.								
Monique (Louvicourt) – probable and possible	589 800	–	–	–	–	–	–	5.93
MSV Resources Inc.								
Eastmain River	1 016 000	0.27	–	–	–	–	17.	15.
Muscocho Explorations Ltd.								
Flanagan McAdam Resources Inc.								
Greenstone Resources Ltd.								
Gwillim mine – preliminary	306 800	–	–	–	–	–	–	10.
Muscocho Explorations Ltd.								
Flanagan McAdam Resources Inc.								
Noranda Exploration Company, Limited								
Gwillim Lake – preliminary	205 700	–	–	–	–	–	–	11.

Table 6. (cont'd)

COMPANY AND DEPOSIT	TONNAGE	GRADE						
		Cu	Ni	Pb	Zn	Mo	Ag	Au
	tonnes[1]	%	%	%	%	%	g/t	g/t
Noranda Inc. Cambior inc. Nova-Cogesco Resources Inc. Silidor (Ribago-Waite Beauchastel) – probable and possible	4 936 300	–	–	–	–	–	–	6.2
NSR Resources Inc. Rand Malartic Mines, Limited Nova-Cogesco Resources Inc. Rand Malartic (Fournière)	60 500	–	–	–	–	–	–	13.
Placer Dome Inc. Western Quebec Mines Inc. Wesdome	1 148 000	–	–	–	–	–	–	4.1
Quebec Explorers Corporation Ltd. Nova-Cogesco Resources Inc. Dubuisson – drill indicated and inferred	237 000	–	–	–	–	–	–	7.23
Rouyn Mining Resources Inc. Lac Fortune – proven, probable and possible	234 050	–	–	–	–	–	–	5.37
Rouyn Mining Resources Inc. Lac Minerals Ltd. Wasamac (pillar)	816 000	–	–	–	–	–	–	3.4
St. Genevieve Resources Ltd. Standard Gold Mines Ltd. Duverny – proven, probable and possible	132 472	–	–	–	–	–	–	5.42
St. Genevieve Resources Ltd. Bay Resources and Services Inc. Stratmin Inc. Jilbey Industries Ltd. Fontana (Duverny) – probable and possible	878 295	–	–	–	–	–	–	5.66
Société Minière Sphinx Inc. Goldstack Resources Ltd. Dubuisson (Malartic Goldfields) – probable and possible	660 000	–	–	–	–	–	–	5.97
Syngold Exploration Inc. Greenstone Resources Ltd. Obalski	172 000	1.68	–	–	–	–	–	3.8
Teck Corporation Golden Hope Resources Inc. Golden Group Explorations Inc. Estrades – drill indicated mineable	1 236 263	0.76	–	–	9.58	–	142.	5.1
Teck Corporation Golden Pond Resources Ltd. Lamaque	348 000	–	–	–	–	–	–	8.2

Teck Corporation Tundra Gold Mines Limited Lamaque	1 100 000	-	-	-	-	-	-	5.8
Western Quebec Mines Inc. Oracle Exploration Inc. Joubi (Dubuisson)	541 370	-	-	-	-	-	-	5.82
Westminer Canada Limited Norbeau mine (McKenzie)	916 000	-	-	-	-	-	-	7.2
Yorbeau Resources Inc. Ellison (A zone) – probable and possible	781 000	-	-	-	-	-	-	6.9
ONTARIO								
Agassiz Resources Ltd. Massive Resources Ltd. Twin Gold Mines Ltd. Lingman Lake – measured, inferred and indicated	1 567 963	-	-	-	-	-	-	8.26
American Barrick Resources Corporation Lenora Explorations Ltd. Worvest – probable, possible and potential	1 400 000	-	-	-	-	-	-	4.59
American Reserve Mining Corporation Associated Porcupine Mines Limited Paymaster – mineable proven, probable and possible	720 688	-	-	-	-	-	-	7.78
Ateba Mines Inc. Roxmark Mines Limited Magnet – mineral inventory	856 000	-	-	-	-	-	-	5.8
Belmoral Mines Ltd. Vedron Limited Vedron (Tisdale-Doloro) – inferred	907 000	-	-	-	-	-	-	7.
Bond Gold Canada Inc. Kenora Prospectors & Miners, Limited Shoal Lake (Cedar Island – Mikado) – drill indicated	783 300	-	-	-	-	-	-	8.6
Camreco Inc. Goldlund (Echo-McAree) – proven, probable and inferred	764 400	-	-	-	-	-	-	5.8
Canamax Resources Inc. Matheson – drill indicated	447 274	-	-	-	-	-	-	7.41
Canamax Resources Inc. Bruneau Mining Corporation Clavos (German & Stock) – drill indicated	583 800	-	-	-	-	-	-	7.5
Chesbar Resources Inc. Murgold Resources Inc. Chester – geological proven, probable and possible	384 234	-	-	-	-	-	-	7.65
Chevron Minerals Ltd. Stroud Resources Ltd. Hislop (Main, Footwall and Creek zones)	532 500	-	-	-	-	-	-	6.7

Table 6. (cont'd)

COMPANY AND DEPOSIT	TONNAGE	GRADE						
		Cu	Ni	Pb	Zn	Mo	Ag	Au
	tonnes[1]	%	%	%	%	%	g/t	g/t
Citadel Gold Mines Inc. Surluga – proven, probable and possible	461 300	–	–	–	–	–	–	7.5
Consolidated Professor Mines Limited Duport – mineable proven and probable	818 600	–	–	–	–	–	–	13
Echo Bay Mines Ltd. Nuinsco Resources Limited Cameron Lake – proven, probable and possible	847 000	–	–	–	–	–	–	6.00
Equinox Resources Ltd. Maude Lake Gold Mines Limited Technigen Corporation Maude Lake – drill indicated	816 000	–	–	–	–	–	–	6.5
ERG Resources Inc. Kirkland Lake (tailings)	32 000 000	–	–	–	–	–	–	0.54
Exador Resources Inc. Stroud Resources Ltd Leckie	175 000	–	–	–	–	–	–	7.37
Freegold Recovery Inc. Kirkland Lake (tailings)	534 000[e]	–	–	–	–	–	–	0.7
Freegold Recovery Inc Placer Dome Inc. Balmerton (tailings)	4 000 000	–	–	–	–	–	–	1.75
Golden Shield Resources Ltd. Northfield Minerals Inc. Northern Ranger Minerals Inc. Rockford Minerals Inc. Larder Lake (Cheminis) – indicated mineral inventory	2 700 000	–	–	–	–	–	–	5.8
Goldpost Resources Inc. New Kelore Mines Limited Hislop – proven and probable	1 633 000	–	–	–	–	–	–	6.65
Granges Exploration Ltd. MacMillan Gold Corp. Mishibishu Lake	1 003 000	–	–	–	–	–	–	5.69
INCO Gold Queenston Gold Mines Limited Anoki – mineral resource	544 000	–	–	–	–	–	–	5.1
Intex Mining Company Limited Frankfield Explorations Ltd. Tully	272 000[e]		–	–	–	–	–	8.6

Jamie Frontier Resources Inc. Pipestone Bay – proven, probable and possible	66 700	–	–	–	–	–	–	13.9
Lac Minerals Ltd. Silverside Resources Inc. Proteus Resources Inc. Garrison – drill indicated	372 000	–	–	–	–	–	–	5.8
Lenora Explorations Ltd. Golden Harker – drill indicated	463 000	–	–	–	–	–	–	5.49
McFinley Red Lake Mines Limited Phoenix Gold Mines Limited McFinley (Bateman) – drill indicated	807 000	–	–	–	–	–	–	6.5
Micham Exploration Inc. Mono Gold Mines Inc. Bannockburn – modified geological	170 000	–	–	–	–	–	–	7.68
Muscocho Explorations Ltd. Jerome Gold Mines Corporation Jerome	396 730	–	–	–	–	–	–	6.5
Muscocho Explorations Ltd. McNellen Resources, Inc. Magino – proven, probable and possible	7 000 000	–	–	–	–	–	–	8.6*
Noramco Mining Corporation Pickle Crow – proven, probable and possible	6 651 084	–	–	–	–	–	–	7.9
Noranda Exploration Company, Limited Golden Princess Mining Corporation Nickel Offsets	544 000	–	–	–	–	–	–	7.9
Noranda Exploration Company, Limited Stan West Mining Corp. De Santis	269 946	–	–	–	–	–	–	5.3
Novamin Resources Inc. Eldorado Resources Limited Cadieux – probable and possible	904 800	–	–	0.87	9.61	–	–	–
Novamin Resources Inc. Rundle – mineral inventory	535 000	–	–	–	–	–	–	6.5
Orofino Resources Limited Orofino (Swayze) – proven, probable and possible	1 498 389	–	–	–	–	–	–	4.8
Placer Dome Inc. INCO Limited Esso Resources Canada Limited Corona Corporation Musselwhite (Snoppy Lake) – geological drill indicated	5 000 000	–	–	–	–	–	–	6.9
Power Explorations Inc. Kasagiminnis – indicated	2 600 000	–	–	–	–	–	–	4.8
St. Andrew Goldfields Ltd. Esso Minerals Canada Taylor (Shoot zone) – geological	1 500 000	–	–	–	–	–	–	4.5

Table 6. (cont'd)

COMPANY AND DEPOSIT	TONNAGE	GRADE						
		Cu	Ni	Pb	Zn	Mo	Ag	Au
	tonnes[1]	%	%	%	%	%	g/t	g/t
United Lincoln Resources Inc. Noranda Exploration Company, Limited Band–Ore Gold Mines Limited Shebandowan – geological	590 000	–	–	–	–	–	7.71	4.73
Zahavy Mines Limited Favourable Lake – probable and possible	891 000	–	–	0.77	1.12	–	165.	8.9
MANITOBA								
Balcor Resources Corp. Lasthope – drill proven, probable and possible	541 000	–	–	–	–	–	–	8.33
Bighorn Development Corporation Wydmar Development Corporation Island Lake – proven, probable and drill indicated	387 000	–	–	–	–	–	–	10.
Granges Exploration Ltd. Alberts Lake – drill indicated	363 000	–	–	–	–	–	–	7.5
Morgan Lake – proven and probable	272 000	–	–	–	15.	–	–	3.4
High River Resources Ltd. Nor–Acme Gold Mines, Limited Snow Lake (underground) – proven and drill indicated	1 851 000	–	–	–	–	–	–	4.97
LynnGold Resources Inc. Bonanza – drill indicated geological	655 000	–	–	–	–	–	–	2.4
Nisku – mineable	187 000	–	–	–	–	–	–	6.5
Rainbow – geological inferred	539 000	–	–	–	–	–	–	8.6
LynnGold Resources Inc. Novamin Resources Inc. Dot Lake – geological	1 100 000	–	–	–	–	–	–	3.8
LynnGold Resources Inc. Trans America Industries Ltd. Burnt Timber	1 000 000	–	–	–	–	–	–	3.81
Mandor Mining Corp. San Antonio – mineable	1 197 000	–	–	–	–	–	–	7.65
Manitoba Mineral Resources Ltd. Mingold Resources Inc. Farley Lake – geological	1 430 000	–	–	–	–	–	–	6.34
Snow Lake Mines Ltd. Silver Hart Mines Ltd. Snow Lake – (No. 3 and Birch zones) – drill indicated	732 000	–	–	–	–	–	–	9.12

Solidor Resources Inc. Prime Explorations Ltd. Squall Lake (near surface) – drill indicated	680 000	–	–	–	–	–	–	3.
Trans America Industries Ltd. LynnGold Resources Inc. Wasekwan Lake – geological	900 000	–	–	–	–	–	–	3.0
SASKATCHEWAN								
Cameco - A Canadian Mining & Energy Corporation Claude Resources Inc. Shore Gold Fund Inc. Jojay – indicated	295 700	–	–	–	–	–	–	7.47
Cameco Golden Rule Resources Ltd. Goldsil Resources Ltd. International Mahogany Corp. Shore Gold Fund Inc. Forks/Transom Lakes – geological	159 000	–	–	–	–	–	–	25.
Claude Resources Inc. Seabee (Laonil Lake) – drill indicated	1 980 000	–	–	–	–	–	–	6.34
Golden Rule Resources Ltd. Goldsil Resources Ltd. Cameco Tower Lake – drill indicated probable and possible	1 100 000	–	–	–	–	–	–	3.4
Granges Exploration Ltd. Cameco Bigstone Lake	3 580 000	1.8	–	–	1.1	–	–	–
Lenora Explorations Ltd. Mary Ellen Resources Ltd. Athona – probable and possible	5 000 000	–	–	–	–	–	–	2.2
Lenora Explorations Ltd. Mary Ellen Resources Ltd. Cominco Ltd. Box – probable and possible	12 400 000	–	–	–	–	–	–	1.8
Placer Dome Inc. Waddy Lake Resources Inc. Komis – drill indicated	1 100 000	–	–	–	–	–	–	3.8
Tyler Resources Inc. Golden Rule Resources Ltd. Cameco Weedy Lake	785 000	–	–	–	–	–	–	4.63
Vista Mines Inc. Bootleg Lake – drill indicated proven and probable	214 494	–	–	–	–	–	–	5.41
BRITISH COLUMBIA								
Better Resources Ltd. Mt. Washington	428 000	–	–	–	–	–	43.5	8.81

Table 6. (cont'd)

COMPANY AND DEPOSIT	TONNAGE	GRADE						
		Cu	Ni	Pb	Zn	Mo	Ag	Au
	tonnes[1]	%	%	%	%	%	g/t	g/t
Catear Resources Ltd. Goldwedge – proven, drill indicated and drill inferred	264 822	–	–	–	–	–	83.8	28.6
Cathedral Gold Corporation Porter Island – drill indicated	565 000	–	–	–	–	–	–	7.
City Resources (Canada) Limited Graham Island (Cinola) – proven and probable mineable	24 800 000	–	–	–	–	–	–	2.1
Cominco Ltd. Delaware Resources Corp. Snip – inferred	1 100 000	–	–	–	–	–	–	26.
Cominco Ltd. Redfern Resources Ltd. Tulsequah Chief – proven and probable	708 000	1.3	–	1.6	8.0	–	99.	2.
Curragh Resources Inc. Cirque (Central Core) – geological	13 000 000	–	–	n.a.	14.2	–	70.	–
Dolly Varden Minerals Inc. Dolly Varden, North Star, Torbrit and Wolf – geological proven, probable and possible	1 272 695	–	–	–	–	–	347.	–
Energex Minerals Ltd. Toodoggone (AL open pit) – proven mineable	276 000	–	–	–	–	–	–	11.
Golden North Resource Corporation Canty – drill proven	597 000	–	–	–	–	–	–	5.1
Golden North Resource Corporation Cathedral Gold Corporation Geomex Development Limited Partnership No. 8 Bralorne – proven and probable	965 000	–	–	–	–	–	–	9.3
Granges Exploration Ltd. Windflower Mining Ltd. Goldfinch – proven and probable	181 000	–	–	–	–	–	–	10.
Gunsteel Resources Incorporated Nugget – proven, probable, marginal and possible	202 900	–	–	–	–	–	–	11.3
Houston Metals Corporation New Nadina Explorations Limited Silver Queen – proven, probable and inferred	1 726 000	–	–	–	6.19	–	328.	3.
Huldra Silver Inc. Treasure Mountain	118 026	–	–	8.39	3.51	–	996.	–
Laramide Resources Ltd. Lara – drill indicated	529 000	1.01	–	1.22	5.87	–	100.	4.73

Levon Resources Ltd. Veronex Resources Ltd. Congress – geological proven, probable and possible	608 000	–	–	–	–	–	–	8.2
McAdam Resources Inc. Tashota–Nipigon Mines Limited Spud Valley (Zeballos) – proven, probable, drill indicated and possible	224 145	–	–	–	–	–	–	14.1
Minnova Inc. Pacific Cassiar Limited Chu Chua – proven	2 500 000	2.0	–	–	0.5	–	9.	0.5
Newhawk Gold Mines Ltd. Corona Corporation Granduc Mines Limited Sulphurets – proven, probable and possible	1 364 849	–	–	–	–	–	691.5	17.3
Noranda Exploration Company, Limited Banbury Gold Mines Ltd. Hedley	4 176 000	–	–	–	–	–	–	2.
Northair Mines Ltd. BP Canada Inc. Rio Algom Limited Willa – drill proven, probable and possible	633 874	0.82	–	–	–	–	–	6.03
QPX Minerals Inc. Placer Dome Inc. QR – drill indicated	900 000	–	–	–	–	–	–	7.
Rea Gold Corporation Adams Lake (Discovery) – drill indicated	242 871	0.57	–	2.14	2.25	–	73.4	6.5
Rea Gold Corporation Verdstone Gold Corporation CK	1 491 000	–	–	1.4	8.6	–	8.6	–
Regional Resources Ltd. Canamax Resources Inc. Procan Exploration Company Limited Midway – geological	1 185 000	–	–	7.0	9.6	–	410.	–
Teeshin Resources Ltd. Canadian–United Minerals Inc. Total Erickson Resources Ltd. Dome Mountain – mineable	289 650	–	–	–	–	–	69.	13.
Welcome North Mines Ltd. Esperanza Exploration Ltd. Tillicum Mountain – proven, probable, drill indicated and inferred	1 890 000	–	–	–	–	–	–	7.2
YUKON								
All–North Resources Ltd. Galactic Resources Ltd. Wellgreen – drill inferred	18 500 000	0.67	0.36	–	–	–	–	–

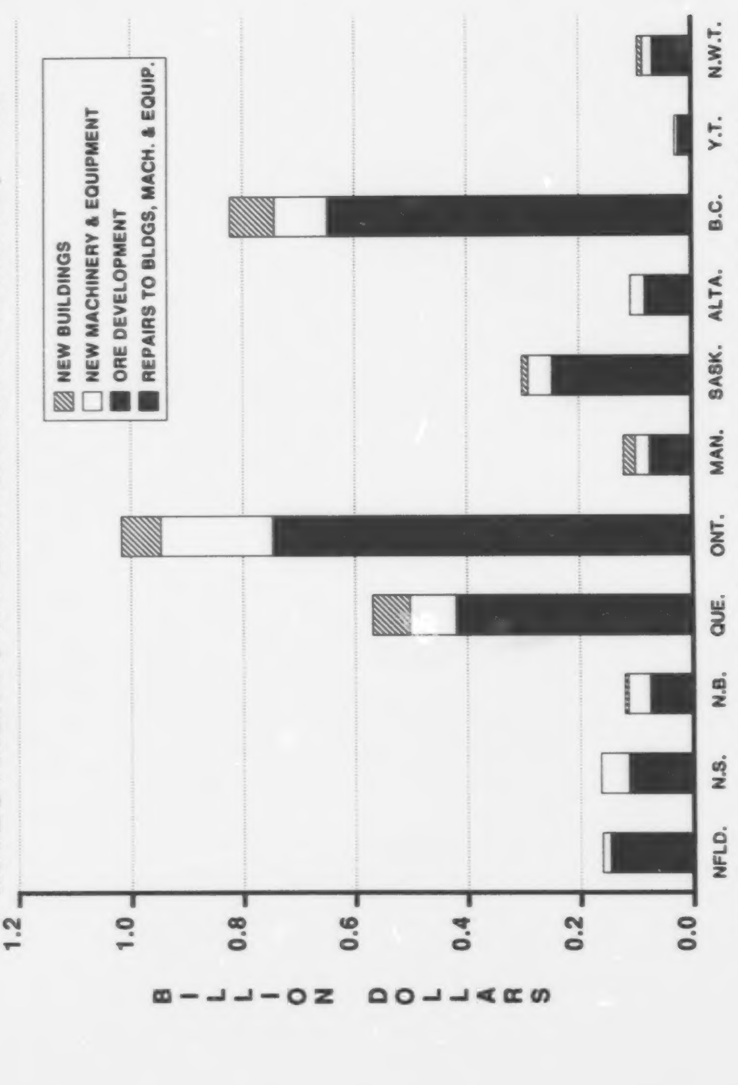
Table 6. (cont'd)

COMPANY AND DEPOSIT	TONNAGE	GRADE						
		Cu	Ni	Pb	Zn	Mo	Ag	Au
	tonnes[1]	%	%	%	%	%	g/t	g/t
Canamax Resources Inc. Mt. Hundere – drill indicated	2 485 000	–	–	8.4	12.9	–	65.	–
Chevron Minerals Ltd. B.Y.G. Natural Resources Inc. Mt. Nansen (Brown McDade zone)	700 000	–	–	–	–	–	34.	7.9
Curragh Resources Inc. DY – geological	21 100 000	–	–	5.5	6.7	–	84.	0.95
Omni Resources Inc. Skukum Gold Inc. Skukum Creek – drill proven and drill indicated	864 000	–	–	–	–	–	288.	7.89
Silver Hart Mines Ltd. Hart – mineral inventory	105 000	–	–	–	–	–	1 920	–
TOTAL Energold Corporation Fairfield Minerals Ltd. Logan – geological inventory	14 000 000	–	–	–	5.13	–	20.	–
NORTHWEST TERRITORIES								
Aber Resources Ltd. Hemisphere Development Corp. Sunrise – probable and possible	1 600 000	–	–	4.2	10.0	–	494.	0.79
Echo Bay Mines Ltd. Comaplex Resources International Ltd. Petromet Resources Limited Kim – drill indicated probable geological	448 780	–	–	–	–	–	–	7.2
Neptune Resources Corp. Johnsby Mines Limited Colomac (Indin Lake) – proven and probable	14 500 000	–	–	–	–	–	–	2.2
Noranda Exploration Company, Limited TOTAL Energold Corporation Tundra (Courageous Lake) – potential in situ inventory	29 484 000	–	–	–	–	–	–	6.9
Orofino Resources Limited Canuc Resources Inc. Coronation Gulf – geologically indicated	780 000	–	–	–	–	–	–	7.5

[1] One tonne = 1.1023113 short tons; 1 gram per tonne (g/t) = 0.02916668 troy ounces per short ton. [2] Combined lead–zinc grade.
n.a. Not available; – Nil; ᵉ Author's estimate.

FIGURE 1

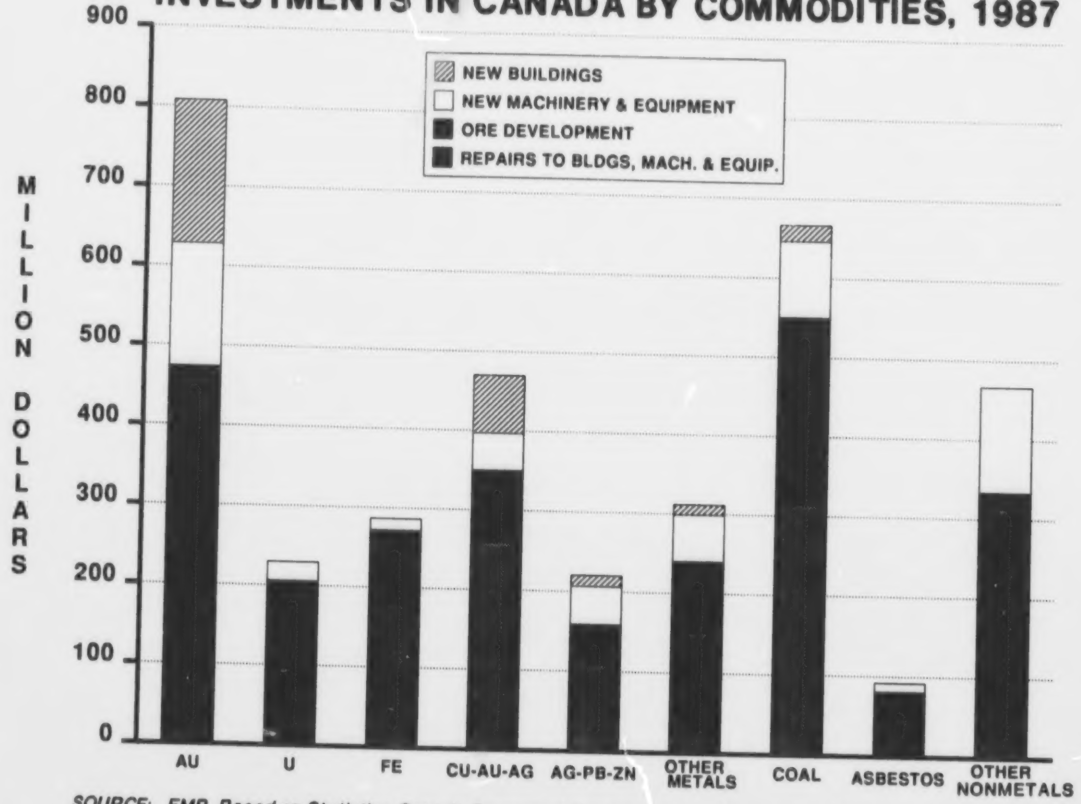
PRODUCTION–RELATED MINE–SITE INVESTMENTS IN CANADA BY PROVINCE, 1987



SOURCE: EMR. Based on Statistics Canada Surveys of Exploration, Development and Capital Expenditures for Mining.

FIGURE 2

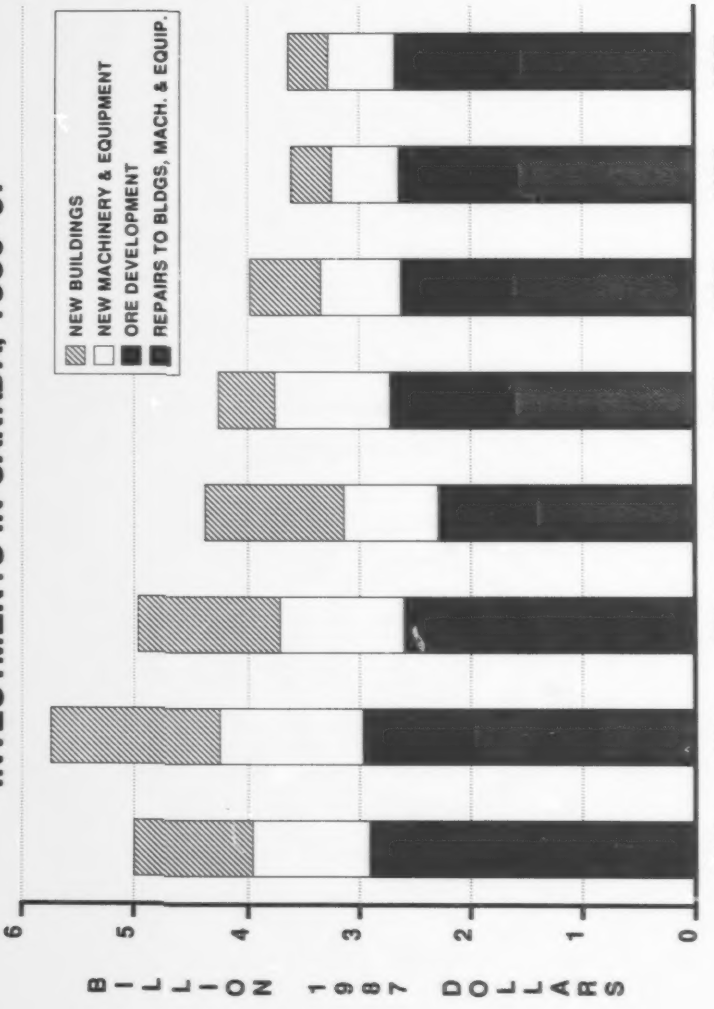
PRODUCTION–RELATED MINE–SITE INVESTMENTS IN CANADA BY COMMODITIES, 1987



SOURCE: EMR. Based on Statistics Canada Surveys of Exploration, Development and Capital Expenditures for Mining.

FIGURE 3

PRODUCTION-RELATED MINE-SITE INVESTMENTS IN CANADA, 1980-87



SOURCE: EMR. Based on Statistics Canada Surveys of Exploration, Development and Capital Expenditures for Mining.

Canadian Mineral Exploration

G. BOUCHARD AND D.A. CRANSTONE

ACTIVITY[1]

Exploration Expenditures: Total off- and on-property field exploration expenditures in 1987 were the highest ever registered in Canadian exploration history, $1139 million, an 86% increase from the $611 million spent in 1986. Minesite exploration (the search for a new mine on the properties of existing mines) amounted to 12% of this total, i.e. $142 million. Related overhead expenditures (land costs, field administration costs and exploration-related head office expenses) add 25% or so to this total. Including an allowance for overhead expenditures, Canadian exploration spending in 1987 totalled approximately $1400 million. Preliminary indications are that in 1988, on- and off-property field expenditures were about the same as in 1987 (Figure 1).

Flow-Through Share Funding: Over the last several years, the financing of mineral exploration has been greatly facilitated by flow-through shares (by which income tax deductions "flow through" to the investor). Funds raised by flow-through shares (Table 1) covered somewhat more than three quarters of all field exploration in 1987 and probably somewhat less in 1988. In 1987, about $1 billion of exploration was financed by flow-through and in 1988 an estimated $850 to $900 million.

In total, for companies listed on Canadian stock exchanges, $1183 million worth of flow-through shares were issued in 1987 up from $673 million in 1986 (Table 1).

In addition to the above placements, flow-through share issues by corporations not listed on stock exchanges may have amounted to as much as several tens of millions of dollars in 1987 and 1988, so that more than $1200 million worth of flow-through shares were sold in Canada in 1987 as compared to more than $700 million in 1986.

The tax-based mining earned depletion allowance (MEDA), which had allowed an extra 33 1/3% deduction for Canadian exploration expenditures (CEE), was reduced from 33 1/3% to 16 2/3% for individuals on January 1, 1989 and for other taxpayers on July 1, 1988. MEDA will be phased out completely at the end of 1989. Corporations that are taxable can deduct CEE and related depletion, if any, against income. Because of the corporate tax savings on the CEE and depletion, taxable companies normally do not issue flow-through shares.

Now that metal prices and cashflow are strong, most producing mining companies are not issuing flow-through shares. Hence it is primarily the junior companies that will be taking advantage of the new Canadian Exploration Incentive Program (CEIP) that, for minerals other than oil and gas, came into effect on January 1, 1989. CEIP, which will apply to exploration expenditures funded by flow-through shares, will provide a 30% incentive on individual company exploration expenditures of up to $10 million, for a maximum cash incentive of $3 million per company. This incentive can be used to attract flow-through share investors. The CEIP incentive provides about the same benefit as depletion, which is being phased out by tax reform. This new program is expected to maintain Canadian mineral exploration activity at a satisfactory level.

Claim Staking: In 1987, the total area of claims staked in Canada was up by 20% from 1986. The largest percentage increases were in the Yukon, New Brunswick, the Northwest Territories, Nova Scotia, Saskatchewan, Newfoundland and British Columbia. Staking was down notably in Quebec, Manitoba and Alberta.

---

[1] Oil and gas are not covered by exploration statistics given here. In the case of new claims recorded, coal is excluded as well.

G. Bouchard (613) 992-4665 and D.A. Cranstone (613) 992-4666 are
with the Mineral Policy Sector, Energy, Mines and Resources Canada.

Statistics available at the end of October suggest that the area staked in Canada in 1988 was smaller than in 1987 in Quebec, Ontario, British Columbia and Nova Scotia; about the same in the Yukon; and higher everywhere else.

Federal-Provincial Exploration Survey: Since 1980, the federal Department of Energy, Mines and Resources Canada has made efforts towards achieving greater interprovincial consistency in the information gathered from industry on exploration activity. Coordination with provincial and territorial officials in the design of provincial surveys that allow nationwide comparisons has led to a much more reliable and detailed set of Canadian exploration data beginning with 1985. Some observations on the results for 1987 activities (see Figures 1 to 6) are given below.

Surface Exploration Drilling: The 5 677 056 m of Canadian surface exploration drilling in 1987 exceeded by 80% the previous record set in 1986 (Figure 1). In the first half of 1988, the level of drilling rose even further, but in the second half it declined in some provinces, most notably in Quebec.

Exploration Expenditures by Province and Territory - 1987 (Table 3 and Figure 2)

- The most active areas remained Quebec and Ontario, which jointly accounted for some 64% of total Canadian exploration spending. In Quebec, 1987 field exploration expenditures were $416 million, a steep rise from the $242 million spent in 1986. In Ontario, expenditures were $308 million, more than twice the $137 million spent in 1986. Early indications are that exploration expenditures in both provinces were down in 1988. Indications are that exploration spending in Quebec dropped off sharply during the second half of the year but that this was not the case in Ontario.

- Field exploration expenditures in British Columbia rose to $143 million in 1987 from $63 million in 1986, in the Northwest Territories to $59 million from $43 million and in Manitoba to $40 million from $26 million. Spending in Nova Scotia and Newfoundland more than doubled, increasing in Nova Scotia to $42 million in 1987 from $17 million in 1986 and in Newfoundland to $28 million in 1987 from $12 million in 1986. Exploration spending was down slightly in 1987 in New Brunswick, and Alberta.

Exploration Expenditures by Commodities Sought - 1987 (Table 2 and Figure 3)

- More than four-fifths of exploration spending in 1987 was directed at precious metals, chiefly gold, up from three-quarters in 1986. Exploration spending for precious metals rose to $951 million in 1987 from $461 million in 1986.

- Field expenditures in 1987 were distributed by commodity target groups as follows:

Precious metals (primarily gold, some silver and platinum-group metals)	83%
Copper, zinc, lead and nickel	11%
Uranium	2%
Coal	1%
Others (miscellaneous metals, nonmetals and unspecified)	3%

- Relative to 1986, the amounts spent on exploration in 1987 were up (+) or down (-) as follows:

Precious metals	+104%
Copper, zinc, lead and nickel	+50%
Uranium	-11%
Coal	-49%

- The decline in field expenditures for base metals exploration as a percentage of total mineral exploration expenditures (general exploration and minesite exploration) continued (Table 3). But despite the decline in percentage terms, field exploration expenditures for base metals rose to $129 million in 1987, up from $85 million in 1986, and the highest level of expenditures for Canadian base metals exploration since 1982.

- The total of exploration spending for commodities other than gold and base metals declined by about 11% in 1987 compared to 1986.

- Canadian field exploration spending for coal fell to only $7.2 million in 1987 from $14.0 million in 1986. This represents the lowest exploration expenditure for coal since 1978.

Regional Exploration Expenditures by Commodities Sought - 1987 (Figure 4)

- Gold was the principal exploration target in 1987 in all provinces and territories except New Brunswick (where base metals exploration spending slightly exceeded that for precious metals) and Alberta (where more money was spent on exploration for coal and for uranium than for all base and precious metals together). In Saskatchewan, exploration expenditures for gold in 1987 were almost double those for uranium, the first year since the mid-1940s that more was spent on gold exploration than on uranium exploration. This increase in gold exploration was largely in the La Ronge region, north of Lake Athabasca and west of Flin Flon, Manitoba.

Regional Exploration Expenditures by Types of Company - 1987 (Figure 5)

- Junior companies were the dominant spenders in British Columbia, the Northwest Territories, Ontario, Quebec and the Yukon.

- In British Columbia, spending by junior companies accounted for slightly more than half of total exploration spending. In Quebec they accounted for two-thirds of total exploration spending.

- Producing companies together with their affiliates accounted for more than half the total exploration spending in Newfoundland, Nova Scotia, New Brunswick, Manitoba, Saskatchewan and Alberta.

- Foreign companies expended 97% of their exploration dollars in Quebec, Ontario, Saskatchewan, British Columbia and the Northwest Territories.

Exploration Expenditures by Types of Companies and Commodities - 1987 (Figure 6)

- Of the total expenditures for precious metals exploration, junior companies contributed about 59% and producing companies and their affiliates about 39%, almost identical to their 55% and 40% shares respectively in 1986.

- Of the money spent on Canadian exploration for base metals, producing companies and their affiliates provided 70% and junior companies 25%.

- In 1987, the search for gold accounted for 73% of the Canadian exploration spending of foreign companies up from 50% in 1986.

- Field exploration expenditures for uranium by foreign companies declined to $5.7 million in 1987 from $16.4 million in 1986. Total Canadian field exploration expenditures for uranium declined by only 10% to $24.5 million in 1987 from $27.3 million in 1986, so there was a significant shift in Canadian uranium exploration from the foreign companies to Canadian uranium producers and their affiliates (who spent $18.1 million in 1987, up from $10.1 million in 1986).

Types of Companies Engaged in Exploration - 1986 and 1987 (Table 4)

- Half (52%) of the Canadian field exploration expenditures were spent by junior companies. 44% by producing companies and their affiliates, 3% by foreign companies and 1% by oil companies. The junior companies spent $94 million more than the seniors.

- Although field exploration spending by oil companies rose to $15 million in 1987 from $9.1 million in 1986, these levels of exploration spending by this group of companies remains far below the $75 million to $100 million (1987 dollars) range of oil company exploration spending from the late 1960s to the early 1980s.

EXPLORATION RESULTS

At least 65 metallic mineral deposits were discovered in Canada in 1987, already an all-time record. The previous record of 50 deposits discovered was set in 1981, which was also the previous record year for exploration spending. Announcements to date of new deposits discovered in 1988 indicate that 1988 will also be an outstanding discovery year.

Experience has shown that the number of generally recognized discoveries for a given year rises with the passage of time. For example, the 1985 discoveries compiled in late 1986 amounted to 30; by late 1987 this total had risen to 43. The number of 1984 discoveries recognized in late 1985 was 12, in late 1986 it had grown to 24, and by late 1987 it stood at 29.

About seven out of every eight of the metallic mineral deposits discovered in 1987 were gold deposits, up from four out of five in 1986. These proportions are approximately equivalent to those of total Canadian exploration expenditures directed at gold in those years. The result of the heavy emphasis on gold exploration has been an increasing number of gold discoveries, which amount to more than 250 for the period 1980 to 1987 inclusive.

Although the number of annual discoveries of metallic mineral deposits has been at high levels over the past decade, the average gross value of their likely metal content is well below the average of the past 40 years. One reason is the shift of discoveries from base-metal deposits to gold deposits, which tend to be smaller. Another reason is a decline in average size of the new base metal deposits found.

OUTLOOK

Canadian mineral exploration expenditures will likely remain high in 1988 relative to the historical trend (Figure 1) because:

i) the momentum of successful exploration for gold in recent years is likely to maintain the gold rush for some time yet;

ii) corporate profitability is notably improved thanks to the sharp price rises for nickel, copper and zinc that started in 1987 and continued through 1988; and

iii) the new Canadian Exploration Incentives Program that went into effect for mining as of January 1, 1989 should help to maintain satisfactory levels of exploration spending by junior companies.

TABLE 1. FLOW-THROUGH SHARES ISSUED FOR COMPANIES LISTED ON CANADIAN STOCK EXCHANGES, 1983-88

Year	Value of Shares Issued
	($ million)
1983	34
1984	139
1985	275
1986	673
1987	1 183
1988P	900

Sources: Montreal, Toronto, Alberta and Vancouver Stock Exchange records as compiled by Mineral Policy Sector, EMR.
P Preliminary.
Note: The value of flow-through shares issued in 1987 cannot be directly compared to actual 1987 exploration expenditures for various reasons: (i) unspent funds may have been returned to investors; (ii) as permitted by tax regulations, some of the money raised in 1987 would not have been spent until January/February 1988; and (iii) some of the funds spent in January/February 1987 were raised in 1986.

TABLE 2. GENERAL AND MINE-SITE FIELD EXPLORATION EXPENDITURES FOR BASE METALS AND PRECIOUS METALS

Year	Base Metals[1]	Precious Metals[2]
	(percentages of total mineral exploration expenditures)	
1975	63	7
1977	42	7
1979	35	12
1981	34	25
1983	42	29
1985	20	65
1986	14	76
1987	11	83

Sources: 1975-83 compiled by D.A. Cranstone, EMR, from individual company responses to Statistics Canada questionnaires, 1985-87, from federal-provincial survey.
[1] Nickel, copper, zinc and lead. [2] Gold, silver and platinum-group metals (probably more than 90% gold).

TABLE 3. EXPLORATION ACTIVITIES BY PROVINCE - 1987

	Expenditures On- and Off-Property		Area of New Claims[1]		Surface Drilling[3]	
	($ millions)	(%)	(hectares)	(%)	(metres)	(%)
Newfoundland	27.7	2	376 362	5	96 362	2
Nova Scotia	41.6	4	624 508	9	181 231	3
New Brunswick	9.1	1	72 748	1	62 242	1
Prince Edward Island	-	-	-	-	-	-
Quebec	415.5	36	890 977	13	2 338 736	41
Ontario	308.1	27	949 231	13	1 568 265	27
Manitoba	40.0	4	212 139	3	208 878	4
Saskatchewan	63.5	6	700 459	10	381 072	7
Alberta	2.5	...	9 408	1	31 101	...
British Columbia	142.5	12	2 269 925[2]	32	505 855	9
Yukon Territory	29.0	3	357 576	5	92 188	2
Northwest Territories	59.0	5	552 385	8	211 126	4
Total	1 138.5	100	7 015 718	100	5 677 056	100

Sources: For expenditures and drilling: Federal-Provincial Field Expenditure Survey. For claim areas: provincial and territorial mining recorders.

[1] Excludes coal. [2] Includes an estimated 70 000 hectares for placer leases. [3] Diamond and other types of surface drilling.

- Nil; ... Amount too small to be expressed.

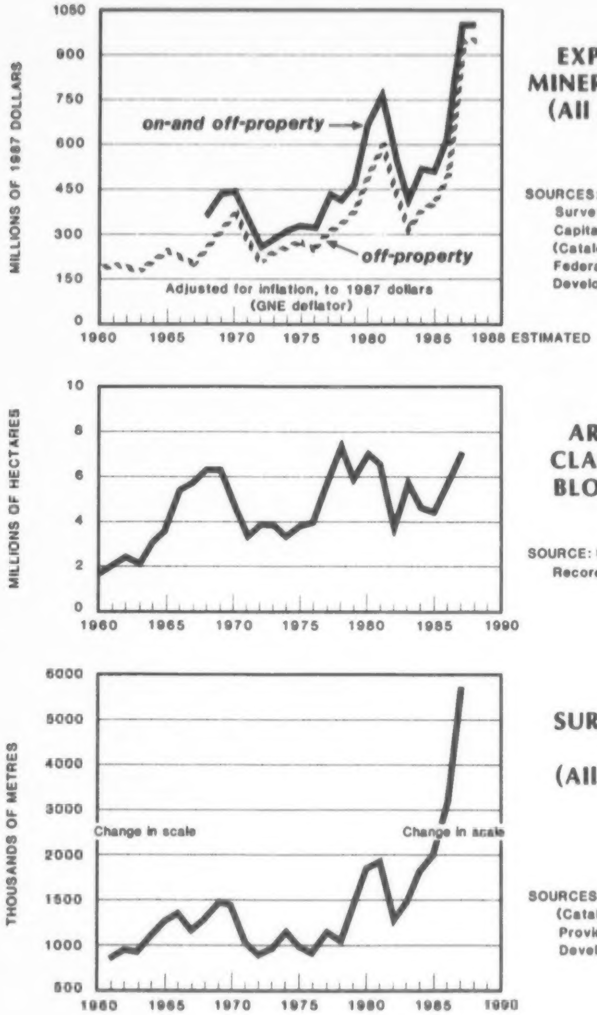
TABLE 4. TYPES OF COMPANIES ENGAGED IN EXPLORATION - 1986 AND 1987

	Expenditures		Surface Drilling	
	1986	1987	1986	1987
	($ millions)		(metres)	
Senior companies (i.e., those with a producing mine in Canada and their affiliates)	269 (44%)	497 (44%)	1 603 100 (51%)	2 666 827 (47%)
Oil companies (excluding the above)	9 (1.5%)	15 (1%)	25 192 (1%)	62 540 (1%)
Foreign companies (excluding the above)	39 (6.5%)	36 (3%)	173 852 (5%)	155 879 (3%)
Others (mainly junior mining companies)	294 (48%)	591 (52%)	1 346 205 (43%)	2 791 810 (49%)
Total	611 (100%)	1 139 (100%)	3 148 349 (100%)	5 677 056 (100%)

Sources: Federal-Provincial Field Expenditures Survey and Statistics Canada "Annual Survey on Exploration, Development, Capital and Repair Expenditures".

Figure 1

MEASURES OF EXPLORATION ACTIVITY



(a)

EXPENDITURES ON MINERAL EXPLORATION (All minerals except oil and gas)

SOURCES: Statistics Canada's Annual Survey of Exploration, Development, Capital and Repair Expenditures (Catalogue 61-216) and Federal-Provincial Exploration and Development Survey.

(b)

AREA OF MINING CLAIMS AND CLAIM BLOCKS RECORDED

SOURCE: Provincial and Territorial Mining Recorders.

(c)

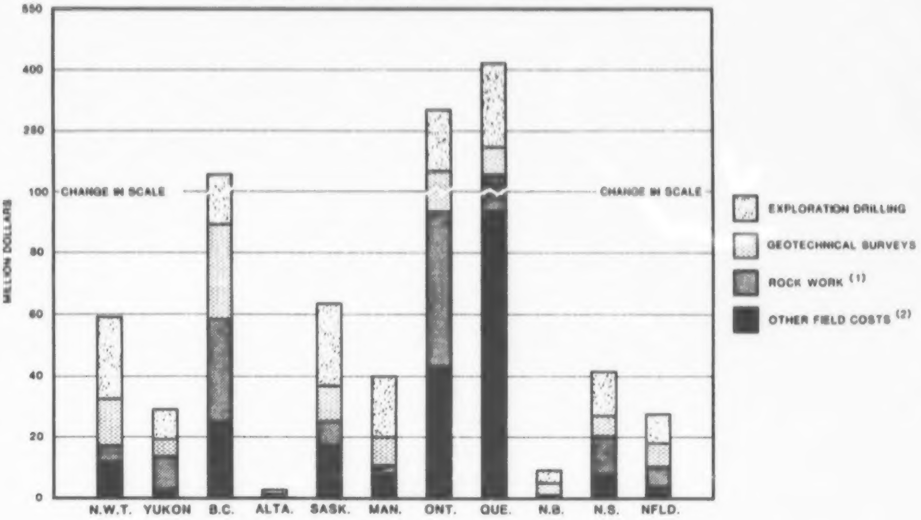
SURFACE DIAMOND DRILLING (All minerals except oil and gas)

SOURCES: Statistics Canada (Catalogue 26-201) and Federal-Provincial Exploration and Development Survey.

Figure 2

EXPLORATION EXPENDITURES BY PROVINCE AND TERRITORY - 1987

Field Work - Physical Work and Surveys



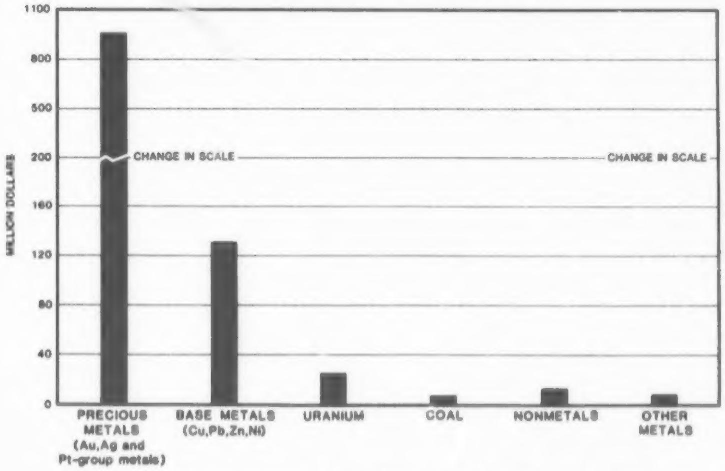
(1) SUCH AS STRIPPING, TRENCHING, SHAFT-SINKING AND UNDERGROUND WORK.
(2) SUCH AS FIELD SUPERVISION AND LINE CUTTING.

SOURCES: Federal-Provincial Field Expenditure Survey and Statistics Canada "Annual Survey on Exploration, Development, Capital and Repair Expenditures".

Figure 3

EXPLORATION EXPENDITURES BY COMMODITIES SOUGHT - 1987

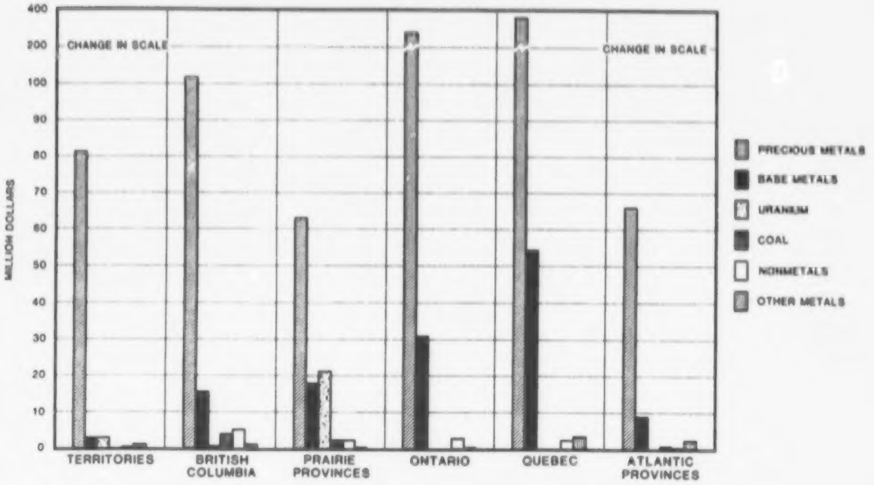
Field Work - Physical Work and Surveys



SOURCES: Federal-Provincial Field Expenditure Survey and Statistics Canada " Annual Survey on Exploration, Development, Capital and Repair Expenditures".

Figure 4

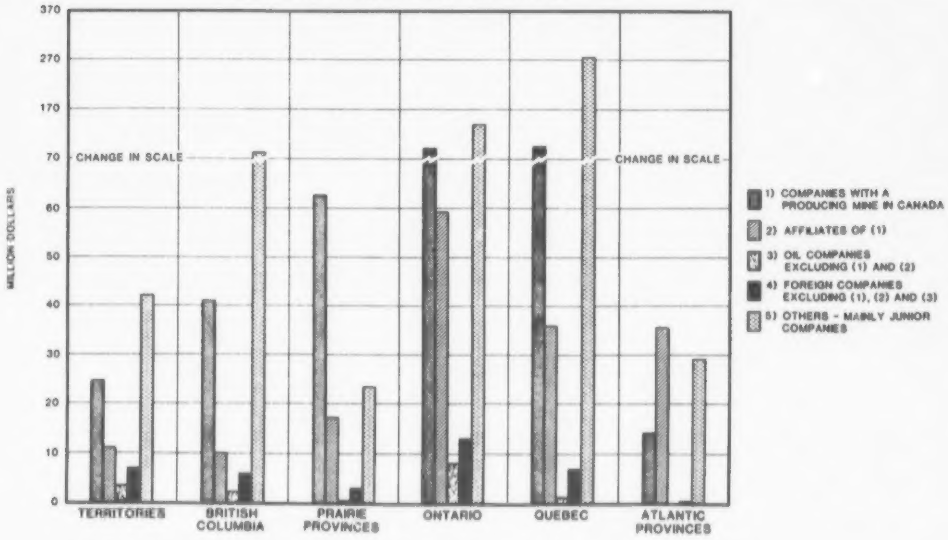
REGIONAL EXPLORATION EXPENDITURES BY COMMODITIES SOUGHT - 1987
Field Work - Physical Work and Surveys



SOURCES: Federal-Provincial Field Expenditure Survey and Statistics Canada "Annual Survey on Exploration, Development, Capital and Repair Expenditures".

Figure 5

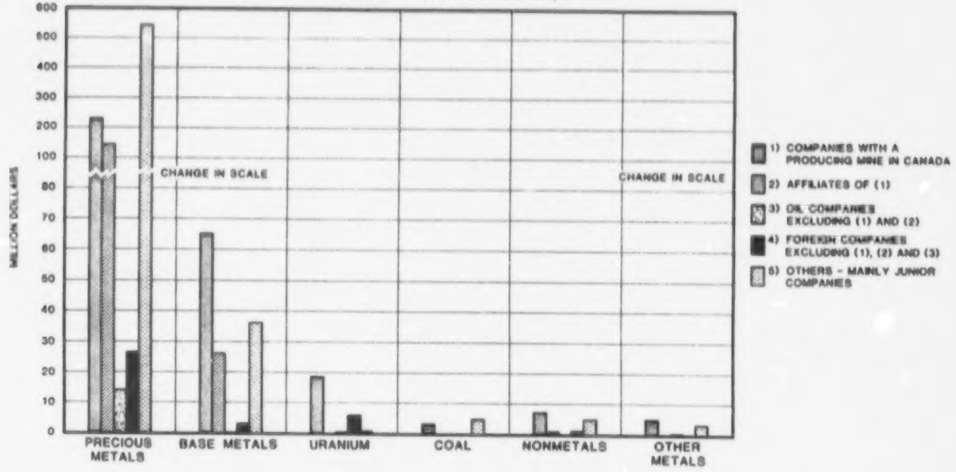
REGIONAL EXPLORATION EXPENDITURES BY TYPES OF COMPANIES - 1987
Field Work - Physical Work and Surveys



SOURCES: Federal-Provincial Field Expenditure Survey and Statistics Canada "Annual Survey on Exploration, Development, Capital and Repair Expenditures".

Figure 6

EXPLORATION EXPENDITURES BY TYPES OF COMPANIES AND COMMODITIES - 1987
Field Work - Physical Work and Surveys



SOURCES: Federal-Provincial Field Expenditure Survey and Statistics Canada "Annual Survey on Exploration, Development, Capital and Repair Expenditures".

Aluminum

G. BOKOVAY

Aluminum prices attained record highs mid-way through 1988 through the combined influences of strong consumption, extremely low inventory levels and heightened speculative activity. With the stabilization of inventories, the expectation of additional supplies from smelter projects nearing completion and the successful renegotiation of labour agreements at several large smelters, prices moderated in the second half of the year. As a whole, aluminum prices were relatively high by historical standards.

Despite some continued erosion of price levels it is expected that the underlying strength in the aluminum market will continue through 1989. However, this strength is dependent upon the avoidance of any slowdown in the western world economies.

The longer range outlook for aluminum consumption is positive although a serious oversupply situation could develop in the early 1990s, when a number of new smelter projects including several in Canada come on-stream. While this oversupply will depress industry profitability in the short term and could force the closure of high cost production capacity, it will benefit the industry by increasing the competitiveness of aluminum vis-a-vis other materials.

SUPPLY: CANADIAN DEVELOPMENTS

Canadian production of primary aluminum during 1988 is estimated at 1.534 Mt compared to 1.540 Mt in 1987. Canadian exports of primary smelter products during the first nine months of 1988 were 861 634 t, virtually unchanged from the same period in 1987. Exports to the United States totalled 610 406 t in the first nine months compared to 645 610 t for the same period in 1987.

Three companies produce primary aluminum in Canada: Alcan Smelters and Chemicals Limited, a subsidiary of Alcan Aluminium Limited; Canadian Reynolds Metals Company, Limited, a subsidiary of Reynolds Metals Company of the United States; and Aluminerie de Bécancour Inc. (A.B.I.), a joint venture of Pechiney S.A. of France, Reynolds Metals Company and Alumax Inc. of the United States, and the Government of Quebec through Société générale de financement du Québec (SGF).

Alcan has smelters at Jonquière, Grande Baie, Îsle Maligne, Shawinigan and Beauharnois, Quebec, and Kitimat, British Columbia, with a combined capacity of 1 075 000 t/y. Canadian Reynolds operates one smelter at Baie Comeau with a capacity of 272 000 t/y. A.B.I.'s new smelter at Bécancour, Quebec has a capacity of 240 000 t/y.

Alcan is the only domestic producer of alumina, the principal raw material for aluminum metal production. The company's refinery, which is located at Jonquière Quebec, has a capacity of approximately 1.2 Mt/y of metallurgical and commercial grade alumina. Bauxite requirements for this facility are imported principally from Brazil, Sierra Leone and Guinea. The production of metallurgical alumina at Jonquière, which totalled 952 000 t in 1987, is consumed at Alcan's reduction facilities in Quebec, supplemented with imported alumina principally from Jamaica. The company's Kitimat plant is supplied with alumina mainly from Australia.

Alumina for the Canadian Reynolds smelter in Baie Comeau is imported from the United States while A.B.I. is supplied from Australia.

At the end of 1988, all Canadian smelters were operating at capacity, with the exception of Alcan's Arvida works in Jonquière where approximately 88% of the plant's 432 000 t capacity was being utilized. It is not anticipated that Alcan will bring this idle capacity back on-stream.

G. Bokovay is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 992-4093.

A strike which closed Alcan's 84 000 t/y Shawinigan smelter in October 1987 was settled in March 1988. The 485 unionized employees at the plant, members of the Confederation of National Trade Unions (CNTU), were reported to have agreed to an 11% wage increase over three years. A similar agreement between Alcan and workers at the Arvida, Îsle Maligne and Beauharnois smelters, represented by the Federation of Aluminium Unions Inc. was also reached in March.

On August 26, unionized employees represented by the Canadian Association of Smelter and Allied Workers staged a work stoppage at Alcan's Kitimat smelter in British Columbia. However, a tentative agreement was reached between the two sides several days later, thereby averting a shutdown of the facility. Terms of the two year agreement included a $1 300 lump sum payment plus wage increases of 5.5% in the first year and 95¢/h in the second year of the contract. Under the previous agreement the basic hourly rate was $17.40.

Alcan Aluminium Limited reported a record consolidated net income of US$931 million for 1988 compared to $433 million for 1987. In addition to favourable market conditions, Alcan attributed the improvement to its strategy of modernization and low-cost excellence.

During 1988 Alcan announced that it was advancing the construction of its new Laterrière smelter in Quebec. Alcan expects the 200 000 t/y plant will be completed by March 1991, some 20 months earlier than originally planned. The company estimates the total cost of Laterrière at more than US$600 million ($715 million). The new capacity will essentially offset the planned closure of 10 of the 14 Soderberg potlines at the existing Arvida smelter. By doing so, the company will lower its operating costs and significantly reduce atmospheric emissions of benzo alpha pyrenes.

In January 1989, Alcan announced that it would spend over US$100 million to modernize and expand its direct chill casting capability at three smelters in North America. This includes $48 million for Kitimat in British Columbia, $22 million for a smelter at Sebree, Kentucky, plus $30 million which has already been spent at Grande Baie in Quebec. Alcan also announced that it was considering plans for a new smelter at Alma, Quebec as part of a continuing modernization program of the company's Quebec smelting operations.

Alcan announced several additional projects during 1988 for the Lac Saint Jean region of Quebec. These include $3 million to produce ceramic-related materials used in the reinforcement of ceramic and metal matrix composite products, and $25 million to manufacture "Dural", a ceramic particle reinforced aluminum. Alcan will also build a new alumina hydrate plant at a cost of $28 million. Alumina hydrate is used in artificial marble, onyx, toothpaste and rubber backing for carpet.

In December 1988, A.B.I. confirmed that it would proceed with a 120 000 t/y expansion to its aluminum smelter in Quebec. The $550 million project will increase capacity to 360 000 t/y by 1991. It was reported that the power contract negotiated between the consortium and Hydro-Québec will run for a period of 26 years. The contract is based on a shared risk concept in which the cost of electricity is tied to market price of aluminum.

A consortium comprised of SGF, Reynolds Metals, Austria Metall A.G., Mitsubishi Metal Corporation, Kobe Steel, Ltd. and Yoshida Kogyo KK undertook a feasibility study for a new 270 000 t/y aluminum smelter. It is expected that the consortium will make a final decision on the project in early 1989. Although several sites were reported to be under consideration, Sept-Îles appears to be the favoured location. In August, it was announced that Prime Minister Brian Mulroney and Quebec Premier Robert Bourassa had agreed to promote that location as the site for the project. It was also reported in the press during August that the federal government had been asked to provide $82 million toward the cost of infrastructure at Sept-Îles as well as for port improvements and the establishment of a rail ferry service.

Vereinigte Aluminium-Werke AG (VAW) was reported to be considering construction of a smelter in Quebec. It had considered a similar investment in the early 1980s but did not pursue the project due to poor market conditions.

In Manitoba, Alumax Inc. and the provincial government discussed the possible establishment of a new aluminum smelter in that province. At year end, the most important issue yet to be resolved related to the cost of power. It was reported that Alumax was seeking a rate of 1.2¢/kWh. During 1988, Manitoba Hydro's published industrial power rate was 2.3¢. According to Alumax officials, Manitoba was just one of the possible sites for a new aluminum smelter. Other locations included Quebec, British Columbia, Iceland and Venezuela.

In British Columbia, Alcan announced a 520 MW expansion of its hydroelectric generating facilities at Kemano. The project is expected to cost $570 million and be completed in 1994. While the company has no immediate plans to build additional aluminum smelting capacity in British Columbia, the Kemano expansion is a necessary precondition for such development. Until Alcan decides to build a new smelter or expand its existing Kitimat plant, the company plans to sell surplus power to the provincial utility.

In 1988, Howmet Corporation of the United States, a subsidiary of Pechiney S.A., purchased the assets of the Canadian based Cercast group of companies, including Cercast Inc. of Montreal and Cercor Inc. of Georgetown, Ontario. Cercast, with other operations in the United States, France and Spain, is one of the largest producers of aluminum investment castings in the western world.

In October, Connecticut Metal Industries Inc. of the United States and Exalloy Metals of Canada announced that they would construct a pilot plant in Toronto to recycle plastic coated aluminum scrap. The plant is expected to process about 90 t/m of feedstock.

In July, it was announced that the federal and Quebec governments would finance, in the form of loans and grants, one third of a $112 million aluminum auto parts plant being built in Quebec by Montupet S.A. of France. The facility, to be constructed in Rivière-Beaudette, will produce precision cast aluminum parts including cylinder heads and intake manifolds.

On February 1, 1989, Reynolds Metals announced plans for a $50 million plant in Louiseville, Quebec that will produce cast aluminum wheels. The plant will have a planned output of 75 000 wheels/y and will employ about 325 persons.

SUPPLY: WORLD DEVELOPMENTS

Western world primary aluminum production in 1988 is estimated at 13.75 Mt, compared with 12.90 Mt in 1987. The International Primary Aluminum Institute (IPAI) reported that the average daily production of aluminum in the western world in December 1988 stood at 38 100 t. This compares to 35 400 t in December 1987. While world smelting capacity increased marginally during the year, the higher production levels recorded in 1988 resulted in large part from the reactivation of inactive facilities in 1987, particularly in the United States.

According to a press report based on a study by Anthony Bird and Associates, the weighted average cost of production for aluminum in the western world increased 16% during 1987 and 1988 to US52.9¢/lb. On an individual country basis, Venezuela had the lowest cost at 38¢/lb., followed by Canada at 47¢/lb., and Brazil at 48¢/lb. The average cost in Europe and Australia was 53¢/lb., Japan 54¢/lb. and United States 60¢/lb.

The report attributed the increase of costs to higher input prices particularly for electricity and alumina in part because some power and alumina contracts are tied to the price of aluminum metal. The report concluded that at an aluminum price of about US75¢/lb., the average cost of production would fall by almost 8% due to lower input costs.

United States

With the start-up of some additional capacity in 1988, the utilization rate at U.S. smelters at the end of the year was approximately 99%. This situation is expected to improve further with some of the remaining 40 000 t/y of unused capacity at two small smelters in the Pacific northwest, scheduled for reactivation in early 1989.

In October 1988, AMAX Inc. announced that its Alumax Inc. subsidiary was selling a 25% interest in its Intalco smelter in Ferndale, Washington and its Eastalco smelter in Frederick, Maryland to a Japanese consortium, comprised of Mitsui & Co., Ltd., Toyo Sash Co., Ltd. and Yoshida Kogyo KK. The transaction represents about 106 000 t/y of primary aluminum capacity and was reported to be worth US$210 million. AMAX stated that the proceeds of the sale would be used to invest in new hydro based primary smelting capacity. For Mitsui, the purchase has enabled that company to regain a major equity position in Alumax, something that it held prior to a buyout in 1986.

During 1988, the Aluminum Company of America (Alcoa) continued work on several projects designed to increase the company's capability to produce aluminum sheet for beverage cans. A new US$140 million continuous cold mill was completed in 1987 at Alcoa, Tennessee, and a US$99 million hot mill and additional coil annealing furnaces is under construction for completion in 1990.

In December 1988, both Alcoa and Reynolds Metals Company successfully completed negotiations with approximately 24 000 U.S. employees on the terms of new labour agreements. Some of the principal features of the new contracts include profit sharing plans, a US50¢/h wage increase, lump sum bonuses and pension improvements. The new agreements cover the period November 1, 1988 to May 31, 1992 and replace contracts that were scheduled to expire beginning in May 31, 1989.

In October, Reynolds announced that it would build a US$125 million cast house to its Listerhill aluminum alloys plant in Sheffield, Alabama. The project is expected to increase sheet ingot capacity from 360 000 t to 450 000 t/y late in 1991. In July, Reynolds announced that it was closing its Grand Rapids, Michigan aluminum extrusion plant by the end of 1988 because of high operating costs.

In April 1988, Kaiser Aluminum & Chemical Corporation reached a tentative agreement with the United Steel Workers of America for a new master labour contract covering about 5 400 workers at 11 plants in the United States. The principal elements of the new agreement include a US50¢/h pay increase, a $1000 signing bonus and a cash bonus tied to the price of aluminum.

In June, Kaiser announced its intention to sell a foil rolling operation in Permanente, California and foil laminating facilities at Belpre, Ohio to TXL Corp. In September, it was reported that Kaiser would reactivate about 18 500 t/y of smelting capacity at Ravenswood, West Virginia which had been closed in 1987.

At the end of October, the Maxxam Group, Inc. completed a leveraged takeover of KaiserTech Limited, the parent company of Kaiser Aluminum. In December, Kaiser Aluminum announced that it would sell its aluminum smelter and rolling facilities at Ravenswood, West Virginia and a can scrap reclamation centre in Bedford, Indiana to Stanwich Partners Inc.

As a result of extremely tight market conditions for metallurgical alumina, Ormet Corp. undertook the reactivation of its Burnside, Louisiana refinery in the second half of 1988. The 550 000 t/y facility had been closed since the beginning of 1986.

At the end of 1988, Pechiney Corporation of the United States owned by Pechiney S.A. of France, completed the takeover of Triangle Industries, Inc. for US$1.3 billion. Triangle, whose assets include American National Can Company, is a major producer of aluminum beverage cans and other packaging materials. During 1987, American National Can was estimated to have consumed approximately 215 000 t of aluminum.

In February 1988, Alcan Aluminium Corporation of the United States announced that it had selected Berea, Kentucky as the site for a new US$50 million can recycling plant. The facility will have an annual capacity of about 110 000 t/y by late 1989. In March, Alcan Aluminium Limited announced that its Alcan Rolled Produits Division would spend US$60 million to modernize aluminum foil rolling facilities in Terre Haute, Indiana. On January 4, 1989, Alcan Aluminium Corporation concluded the purchase of the assets of Jarl Extrusions Inc. Jarl employs approximately 275 workers at plants in Tennessee and New Hampshire.

In July 1988, it was reported that Nichols Homeshield Inc. would build a new aluminum rolling complex in DavenPort, Iowa. The cost of the facility, which would have a capacity of between 45 000 and 68 000 t/y, is estimated at US$30 million.

Also during 1988, Southern Alloys Company began work on a new secondary aluminum plant in Shelbyville, Tennessee. The 32 500 t/y facility was scheduled for completion in February 1989. Elsewhere in the United States, Consolidated Aluminium Corp. (Conalco) announced that it would build a 45 000 t scrap recycling plant at Bens Run, West Virginia. The US$15 million facility is expected to be completed in the third quarter of 1989. In addition, Imco Recycling Inc. announced in November that it would construct a new US$8 million recycling plant in Morgantown, Kentucky.

This plant is expected to increase the company's secondary recovery capacity to 185 000 t/y.

In August, Industria Venezolana de Aluminio CA (VENALUM) of Venezuela acquired a 20% stake in Wells Aluminum Corporation, a large U.S. extruder. It was reported that VENALUM will supply Wells with 40% to 60% of its primary aluminum requirements, estimated at over 60 000 t/y.

In early 1988, the Bonneville Power Administration (BPA) stated that its incentive scheme to improve energy utilization at aluminum smelters in the Pacific northwest would stimulate an estimated US$300 million in spending by aluminum producers over the next three to four years. Under the program, BPA will pay US0.5¢/every kWh saved in the production of aluminum metal.

Jamaica

In March 1988, the Jamaican government and Alcoa resolved a dispute concerning Alcoa's intention to resume control of its Clarendon alumina refinery. Following Alcoa's closure of the plant in 1985, the facility was re-opened in July of that year and operated by the company on behalf of the government. Under the terms of the agreement, the Jamaican government increases its equity position in the refinery from 6% to 50% while Alcoa can export bauxite. Alumina production at Clarendon will be increased from 750 000 t/y to 1 Mt/y and a new mud disposal pond will be built. In turn, Alcoa will accept Jamaica's bauxite levy. In September, the bauxite levy was increased to US$22.60/t, retroactive to January. The rate in effect at the end of 1987 was US$18.59/t.

Jamaica reduced its levy by 50% for alumina producers, including Alcoa, who had taken steps to increase output to full capacity, but the companies are now subject to a 33.3% tax on profits, from which they had been previously exempt.

In August 1988, the Jamaican government granted Alcan Aluminium a similar levy reduction, in return for a commitment by the company to increase production at its two alumina refineries from 860 000 t/y to 950 000 t/y in 1989 and eventually to 1.1 Mt/y.

In mid-September, Hurricane Gilbert forced the closure of alumina refining operations on the island of Jamaica and approximately 10 days of production was lost.

Also in Jamaica, Kaiser Aluminum and Reynolds Metals announced in December that they would re-open their 1.2 Mt/y Alpart alumina refinery by the end of March 1989. The refinery was closed in 1985 because of high operating costs and depressed market conditions. Subsequent to the re-start announcement, it was reported that Reynolds had divested its 50% interest in the Alpart plant to Kaiser and Hydro Aluminium a.s. As a result of this transaction, Kaiser increased its ownership to 65% while Hydro took a 35% equity position. The new partners plan to operate the Alpart plant at about 1 Mt/y.

South America

Despite the uncertainty caused by allegations of corruption against top executives of Venezuela's aluminum industry, political controversy over the government's massive spending program for the aluminum sector, and debt repayment problems caused by the slump of world oil prices, significant progress was achieved during 1988 toward the attainment of that country's goal to produce over 2 Mt of primary aluminum by the year 2000.

VENALUM, Venezuela's largest producer, completed a modernization program at its smelter in Puerto Ordaz in 1988 which added 58 000 t/y of capacity. At the end of the year, the company inaugurated a 118 000 t/y potline which, when completed in 1989, will increase total capacity to 456 000 t/y. Venezuela's other existing producer, Aluminio del Caroni SA (Alcasa), is adding an 84 000 t/y potline to its smelter, also at Puerto Ordaz. When the expansion is completed in August 1989, the company's smelting capacity will be increased to 204 000 t/y. An additional expansion to 400 000 t/y is planned for the 1990s.

In February 1988, the Venezuelan government announced an agreement with Pechiney S.A. and Austria Metall A.G. to build a US$620 million smelter at Puerto Ordaz. The smelter, to be known as Alamsa, will have a capacity of 180 000 t/y. Completion of the project is scheduled for 1991. Ownership of the smelter will be Austria Metall 40%, Pechiney 30% and Alcasa 30%. It is expected that the plant will utilize Pechiney's new 280 000 amp reduction cells. It was also reported that the Venezuelan government had undertaken a US$240 million debt-equity swap with the foreign partners to finance Alcasa's share of the project's cost.

In early 1988, the Venezuelan government through Corporacion Venezolana de Guayana (CVG) signed a letter of intent with Alcoa and Suramericana de Aleaciones Laminadas C.A. (SURAL) to build a 120 000 t/y smelter at a cost of US$360 million. The smelter is expected to come on-stream at the end of 1990 and will be owned 40% each by Alcoa and SURAL and 20% by CVG. The plant, to be known as Alusur, will utilize Alcoa technology.

In April, it was announced that Alcasa would build another 180 000 t/y smelter to be known as Aluguay, in a joint venture with Swiss Aluminium Limited (Alusuisse) and Alumax.

In June, the Governments of Venezuela and Italy signed an agreement to build a new 380 000 t/y smelter in Puerto Ordaz. The project, to be known as Aluyana, is expected to cost US$870 million: Ownership of the facility will be CVG 49%, the Italian state-owned companies Italimpianti S.A. and Techanit S.A. 49% and private Venezuelan companies 2%. The first phase of the project, comprising 195 000 t/y of capacity, is expected to be completed by 1991.

In October it was reported that the Government of Venezuela had signed a letter of intent with Organisation Diego Cisneros (ODC), a large Venezuelan investor group, for another 190 000 t/y smelter to be known as Aluminios de Angostura (Aldanca). The cost of the project is estimated at US$660 million.

The proposed Alisa smelter, first announced in 1987, is now expected to begin production in 1990. The 120 000 t/y smelter will be owned 25% by CVG with the remainder held by private Venezuelan companies.

In order to support enormous growth of aluminum smelting capacity, the state-owned Bauxita Venezolana, CA (Bauxiven) will expand its recently developed bauxite operations at Los Pijiguaos to produce 1 Mt in 1989 and 8 Mt by the year 2000. Similarly, the Venezuelan alumina producer, Interamericana de Alumina CA (Interalumina), will expand production from 1.35 Mt in 1987 to 2 Mt by 1990, 3 Mt in the mid-1990s and to 4 Mt by the end of the century.

In Surinam, the Suriname Aluminum Company (Suralco), a subsidiary of Alcoa, announced the restart of 30 000 t/y of capacity at its aluminum smelter. The start-up was expected to be completed in July 1988. The smelter was closed in January 1987 after a guerrilla attack on power lines.

In October 1988, it was reported that Hydro Aluminium was examining the feasibility of restarting Guyana's 300 000 t/y Linden alumina refinery. The refinery was closed in 1982.

During 1988, construction began on phase II of 320 000 t/y Albras smelter project in Brasil. It is expected that full production will be reached in 1992. The smelter is owned by Companhia Vale do Rio Doce (CVRD) and Nippon Amazon Aluminum Co. (NAAC).

At the end of 1988, it was reported that CVRD would resume construction on the 800 000 Alunorte alumina project and that capacity would be increased to 1.1 Mt. The project was stopped in 1986 when NAAC suspended funding. CVRD was also reported to be looking for potential partners for the project, including Alcan Aluminio do Brasil S.A. and Mineraçao Rio do Norte, S.A. (MRN) of which Alcan controls 24%. The facility is now expected to be completed in 1992 at a cost of US$700 million.

In January 1989, it was reported that Billiton Metais SA was expanding the Alumar smelter in Brasil by 83 000 t/y. Although the existing smelter is owned jointly with Alcoa Aluminio S.A., Billiton will finance the entire cost of the project and hence have full control over this incremental production.

Australia

In June 1988, The Broken Hill Proprietary Company Limited (B.H.P.) completed the sale of its 20% stake in the 1.1 Mt/y Worsley alumina refinery to its existing partners including Reynolds Australia Alumina Ltd., Shell Co. of Australia Ltd., and Kobe Alumina Associates (Australia) Pty Ltd. An earlier attempt by B.H.P. to sell its holdings to Hydro Aluminium was blocked by the partners.

In August, Pechiney began a feasibility study for a new 370 000 t/y smelter in Western Australia. The cost of the plant, including an associated power plant, is estimated at US$2 billion. Earlier in 1988, the Western Australia government announced that it had received a proposal to build a new 280 000 t/y smelter. It was reported that this plant might make use of Soviet technology.

In September, the second phase of the new 300 000 t/y Portland aluminum smelter was completed, six months ahead of schedule. The facility is owned by Alcoa of Australia Limited (45%), Government of Victoria (35%), First National Trust (10%) and China International Trust Investment Corp. (10%).

Asia

In an attempt to achieve domestic self sufficiency in aluminum, the People's Republic of China has undertaken an extensive development program to increase production. The goal of the existing five year economic plan (1986-1990) is to increase output to 900 000 t/y. Some of the current projects include the 100 000 t/y Pingguo aluminum smelter in Guangxi, the 100 000 t/y Qingtongxia smelter in Ningxia province, the 200 000 t/y Zhongzhou smelter in Henan province and the 500 000 t/y Shanxi alumina refinery.

In August, it was reported that Sumitomo Metal Industries, Ltd. had sold its mothballed 100 000 t/y Sakata aluminum smelter to the Peoples' Republic of China. The relocation, which is expected to take 15 months, will be to Handan in Hebei province.

In the second half of 1988, the Chinese government announced a ban on the export of several metals including aluminum because of severe domestic shortages.

National Aluminium Co. Ltd. (Nalco) of India announced at the beginning of 1988, the completion of the second phase of its 800 000 t/y alumina plant in Orissa state, although full production is not expected to be attained until 1989. In July, it was reported that Nalco was experiencing technical problems during the start up of its 218 000 t/y Orissa smelter. The plant had been expected to reach full operating capacity by the end of 1988. In September, Kaiser Aluminum completed the divestiture of its 26.7% interest in Hindustan Aluminium Corp. Ltd. (HINDALCO).

In November 1988, it was reported that an agreement had been reached between China National Metals and Minerals Import and Export Corporation, Amari plc and several U.S. companies to build a new 240 000 t/y smelter in Qatar. The US$1.2 billion plant is expected to come on-stream in 1991. The project was originally planned for Umm Al Quwain Aluminium Company (UMALCO) in the United Arab Emirates but had to be moved because of problems related to energy supplies.

In December 1988, Aluminium Bahrain B.S.C. announced that it was considering increasing the size of its Alba smelter to 400 000 t/y. Earlier in the year it was reported that the capacity of the smelter would be increased from 180 000 to 205 000 t/y through technical improvements.

In Saudi Arabia, it was reported in early 1989 that the government had approved plans for the construction of a 210 000 t/y smelter at Yanbu. The project is expected to cost US$640 million. The facility will be owned by Saudi Cable Company and state investment corporations.

Europe

In August, it was reported that Comalco Limited of Australia had signed an agreement with the U.S.S.R. to undertake a feasibility study for an aluminum refinery and smelter complex on the Soviet Pacific coast. According to the same report, the smelter would probably have a capacity of about 500 000 t/y. It was also reported that Hydro Aluminium and a West German company had submitted a tender for the construction of a new 500 000 to 600 000 t/y aluminum smelter at Sayansk in Siberia.

In November it was reported that Pechiney and the government of the U.S.S.R. had formed a joint venture to modernize aluminum fabrication facilities at the Kanaker plant in Soviet Armenia. It was also reported that the two sides were considering other joint venture projects including the construction of two potlines at Saian in Siberia.

In June 1988, it was announced that Hydro Aluminium would undertake a feasibility study on behalf of the Norwegian government for a new 200 000 t/y smelter at Mo i Rana in Norway. The government is interested in such a project as a means of providing job opportunities for workers employed at a nearby money-losing steelworks. At the end of 1988, Hydro Aluminium announced that it was cutting the size of its Norwegian workforce by 1 300 to 6 300 in order to improve cost efficiency.

In France, Pechiney and Electricité de France announced in November that they would build a new 194 000 t/y smelter at Dunkirk. According to a press report, the power rate at the new facility would be US10 mills/kWh. The new US$750 million smelter will replace 95 000 t/y of capacity at Pechiney's Nogueres and Riouperoux plants which will be closed in 1991. In response to his announcement workers at the Nogueres smelter blocked shipments from that plant for approximately four weeks.

In Spain, Industria Espanola del Aluminio S.A. (Inespal) announced in June that it would increase alumina refining capacity at its San Ciprian plant from 800 000 t/y to 900 000 t/y and eventually to 1 Mt. The company's smelter at San Ciprian, which suffered damage during a 1987 work stoppage, reached full production in May 1988. In August, Alcan Aluminium announced that it intended to sell its 23.9% share of Inespal. However, by year-end no buyer had apparently been found.

In Iceland, a consortium of European companies including Swiss Aluminium Limited (Alusuisse), Austria Metall A.G., Gränges Aluminium AB of Sweden and Aluminet Beheer BV of the Netherlands undertook a feasibility study for a new 90 000 t/y to 110 000 t/y smelter in Iceland. The study is expected to be completed in the spring of 1989. It was also reported that Alusuisse was examining the feasibility of increasing its existing 88 000 t/y Isal smelter in Iceland to about 180 000 t/y.

Recycling

The production of secondary aluminum in the market economy countries during 1988 is estimated at 5.0 Mt, up from 4.53 Mt in 1987. This increase is due primarily to the impact of sharply higher prices for primary aluminum and to some degree to continuing improvements in the scrap collection system and the promotion of recycling.

The most important sources of aluminum scrap in the United States, the largest secondary producer, are the packaging and transportation sectors. The largest single source is used beverage containers. During 1988, it is estimated that the recycling yielded approximately 57% of the 79.1 billion cans shipped or roughly 750 000 t. In comparison, the recycling rate in Japan for the year ending March 31, 1987 was 41.5%.

In Canada, Alcoa Recycling Co. Inc. and Pacific Metals Limited established a collection and processing network for used aluminum beverage containers in Saskatchewan. Aluminum beverage containers, which were approved for sale in that province in the spring of 1988, are subject to a refundable 5 cent deposit charge and a 2 cent environmental charge to pay for the collection system.

CONSUMPTION AND USES

Western world consumption of primary aluminum in 1988 is estimated at 14.0 Mt, an increase of 2.8% over 1987.

Aluminum's low density, high strength and corrosion resistance make it suitable for use in alloyed and unalloyed forms in a wide variety of products for both the consumer and capital goods markets. The principal uses of aluminum are in the transport equipment, construction, packaging and electrical industries.

In the transportation sector, aluminum is widely used in the manufacture of automobiles, buses, trucks, trailers, railroad rolling stock and is the principal metal in aircraft. In recent years, aluminum has made significant inroads into the automobile parts manufacturing industry at the expense of steel/cast iron and copper/brass. Important applications include wheels, radiators, engine heads and blocks, intake manifolds, pistons, transmission housings and other power train parts. It is reported that the average North American car in 1988 contained about 160 pounds of aluminum compared to 139 pounds in 1986. The principal reasons for this increase are related to general weight and size reductions of automobiles and to the unique weight distribution requirements of front wheel drive cars. While aluminum offers unique benefits for automobile applications, manufactures are extremely sensitive to price changes for aluminum and other competing materials. With the rapid escalation of aluminum prices in 1988, aluminum faces increasingly intense competition from other metals.

A potential new application for aluminum in the automotive industry is in the production of car bodies. While there are several variations of this technology, including one developed by Alcan that utilizes adhesively bonded sheet aluminum, most claim weight savings of up to 50% over steel.

In the aircraft industry, aluminum faces intense competition from titanium and a new generation of composite materials that are lighter and stronger than conventional aluminum alloys. The aluminum industry has responded through the development of new aluminum-lithium alloys. These offer weight savings of up to 15% in new design applications without requiring changes to tooling or fabrication techniques.

In the railroad equipment industry, Alcan, through a joint venture with Thrall Car Manufacturing Co., has developed a new coal car that can carry 20 000 pounds more than a conventional steel car. While more expensive to purchase, the user is more than compensated through operating savings of 8% to 10% and lower maintenance costs.

The packaging sector continues to be the fastest growing market for aluminum. This market is dominated by the U.S. although Japan has had the largest growth rate in recent years.

The largest single segment of this market is in aluminum beverage cans. While aluminum has virtually eliminated other materials in the large U.S. market, there were suggestions in 1988 that steel could regain some share of the market as a result of sharply higher aluminum prices. Despite the higher prices, aluminum does benefit from long-standing consumer acceptance and a good record as a recyclable material.

In the electrical field, aluminum extensively replaced copper in wiring and power transmission in the 1960s but, while it has maintained the market for power transmission applications, local restrictions and consumer resistance have substantially lessened the demand for aluminum in electrical wiring. Aluminum has however gained acceptance in various communications and computer applications. While there have been some gains for aluminum in electrical applications both in Japan and in Europe, overall consumption has remained fairly constant due to slumping demand in the United States.

In the building and construction industry, major uses of aluminum include residential siding, window and door frames, plus screens, awnings and canopies. In recent years, aluminum has faced intense competition from vinyl in residential siding and from wood in framing applications. While this market in the United States provided some growth for aluminum during the period 1984-87, a slowdown of the construction industry in that country during 1988 caused demand to fall.

Some of the most promising new applications for aluminum are based on a family of new metal matrices. One example is "Dural", developed by Alcan which is aluminum reinforced with silicone carbide ceramic particles. While outperforming traditional aluminum alloys, it can be fabricated with the same techniques. It also has greater specific strength and is lighter than steel and is less expensive than titanium. Initial markets for this material are expected in sporting goods, cast products and small engine components. Potential applications are also expected in the automotive and aerospace industries.

A relatively new market for aluminum is in the production of compact audio discs (CDs). While the quantity of metal required per unit is extremely small, CDs could replace all traditional recording media.

Another potential application is in Alcan's new air cell battery, which produces electricity from the oxidation of aluminum metal. The main advantages of this battery are long shelf life, low weight before activation and constant power output. It is expected that initial applications will include reserve lighting, promotional signage lighting and back-up power systems.

TRADE

With the geographical re-structuring of the aluminum smelting industry expected to continue from high cost energy locations in Europe and the United States to low energy cost sites in Latin America, Canada and the Middle East, international trade in aluminum will grow significantly.

At present, Canada is the largest exporter of primary aluminum in the world, followed by Norway, Australia and Brazil. With the construction of a number of new smelters expressly for export markets, this group will be joined by Venezuela and the Middle East region.

In July, the U.S. International Trade Commission made a final determination that aluminum redraw bar from Venezuela was injuring U.S. industry. This ruling led to the imposition of countervailing and anti-dumping duties of 38.4% and 5.8% respectively. The case against Venezuela was initialed by Southwire Co. in July 1987.

The most important impediment to freer aluminum trade and one which inhibits the most efficient utilization of resources is the relatively high level of tariff protection applied by the European Community.

MARKETS, PRICES AND STOCKS

In September 1988, the London Metal Exchange (LME) and the Japanese government reached an agreement on the establishment of LME warehouses in Japan. These warehouses are expected to begin operations on July 19, 1989. In 1987, the LME opened warehouses in Singapore and is seeking to establish similar depots in North America. It is expected that the expansion of the LME network will ease the backwardation of LME prices that has persisted since 1986, by improving the availability of metal.

The LME ceased the trading of its standard grade aluminum (99.5% purity) contract on December 21, 1988. The LME expects that its new contract based on more widely available high grade (99.7% purity) metal will be less susceptable to squeezes/manipulation and therefore significantly reduce market volatility.

Aluminum prices for high grade (99.7%) metal on the LME, which averaged US91.2¢ in January 1988, increased steadily through the first half of the year on the strength of buoyant demand and low inventory levels. Pushed by heightened speculative activity, prices reached a record high of US$1.95/lb. in June.

With the expectation that the critically tight supply situation would ease somewhat, prices declined through July, August and September. The average price in September was US$1.12/lb. For the remainder of the year, prices were relatively stable with the average for December being $1.14/lb.

While quotations on the LME, particularly for spot metal, reached unprecedented levels and experienced extreme swings, the physical markets have been characterized by more moderate price increases and significantly less volatility. In the important U.S. can sheet market, major producers instituted several price freezes during 1988 in an attempt to lessen the competitive threat from steel and to a lesser extent from imports of aluminum.

Spot alumina prices skyrocketed during 1988 with transactions reported to be in excess of US$700/t. This compares to quotations in a range of US$160-170/t during the second half of 1987.

The International Primary Aluminum Institute (IPAI) reported that total inventories of aluminum (including scrap, primary and secondary ingot, metal in process and finished mill products) in December 1988 stood at 3.101 Mt compared to 3.050 Mt in December 1987 and 3.598 Mt in December 1986. According to IPAI, primary metal stocks in December 1988 were 1.487 Mt compared to 1.390 Mt a year earlier.

HEALTH, SAFETY AND ENVIRONMENT

Alzheimer's disease is a degenerative condition affecting the brain, the cause of which is not known. However, there have been suggestions that aluminum and/or aluminum compounds may play a role in the development of this disease. In this regard, early studies reported that Alzheimer sufferers had a higher than normal concentration of aluminum in their brain tissue. In addition, the injection of aluminum salts into the brains of laboratory animals was reported to produce lesions in the brain.

However, more recent research has revealed that the aluminum induced lesions are quite different, both chemically and structurally, from the lesions found in diseased human brains. In addition, it has been found that aluminum levels in the brain increase slightly with the aging process but not necessarily in association with the progression of Alzheimer's disease. Exhaustive research on both the affects of aluminum in the body and Alzheimer's disease is continuing.

Aside from the possible health hazards of aluminum use there are several environmental issues pertaining to the production of both alumina and aluminum.

The waste product from the processing of bauxite to alumina (Bayer process), an alkaline residue known as red mud, presents a significant problem because of its toxicity and the large volume of production (estimated at 40 Mt/y of solids worldwide). While the construction of sealed impoundment areas has been an effective method for dealing with this problem, it is relatively expensive and space intensive - space that will be unsuitable for any other use. In response to this problem, the industry has developed various dry-stacking techniques, which are useful both in terms of reducing the land requirements for a specific volume of waste material and most importantly for permitting the utilization of the land for purposes such as agriculture at some future date. An alternative method of disposal, and one which the industry is deeply involved, is in the development of uses for red mud. One of the most promising applications is in the production of concrete products.

A more serious environmental issue for the aluminum industry relates to the emission of fluorides from the Hall - Heroult smelting process. For older smelters which utilize Söderburg technology, the production of polycyclic aromatic hydrocarbons (PAHs) which are suspected cancer causing agents, is another serious concern.

As stated earlier in this report, Alcan is building a new smelter at Laterrière, Quebec which, when commissioned, will replace most of the company's Söderburg potlines at Jonquière. The latest generation of aluminum smelters including Laterrière utilize a pre-baked anode which largely eliminates harmful emissions of PAHs. Moreover, newer smelters incorporate fume collection systems that utilize scrubbers to remove most fluorides. In this regard, Alcan has reported that 98% of its fluoride emissions are captured at its Grande Baie smelter while A.B.I. claims a 99% removal rate for its Bécancour smelter.

In addition to the construction of a new smelter at Laterrière, Alcan plans to continue the replacement of older capacity in Quebec. The company expects to have completed this modernization by the year 2015.

During 1988, the U.S. Environmental Protection Agency placed spent potliner on a list of hazardous wastes. The change, which becomes effective in 1989, is expected to cost the U.S. aluminum industry an extra US$30 to $40 million in disposal costs. The industry believes that existing incineration methods are effective in dealing with the fluoride and cyanide components of this material.

OUTLOOK

The aluminum industry continues to undertake considerable research and development for new aluminum based products and fabrication techniques. Some of the more promising are new aluminum based matrix and composite materials, amorphous alloys, powder metallurgy, adhesive bonding techniques and superplastic forming.

Despite the fact that there is considerable potential for the application of these materials or techniques, their short-term impact on the aluminum industry is expected to be quite minimal owing to the small size of markets, slow acceptance and lengthy periods required for the adoption of new production techniques. Even if an advanced aluminum product can significantly out perform competing materials, growth can be constrained by the high cost of production. At best, the potential benefits of these new materials such as are offered by new aluminum lithium alloys, will simply slow the market penetration of competing materials in traditional applications of aluminum.

Nevertheless, consumption in traditional markets is expected to provide continued growth of overall demand. In this regard, aluminum consumption for the period 1989-2000 is forecast to grow at an annual average rate of 1.5%.

The packaging industry, on which the industry has depended for much of its growth in the 1980s, is expected to continue its strong performance. While the United States may provide only limited growth opportunities due to rising recycling of used beverage cans, significant growth of aluminum packaging in other regions is anticipated.

Additional growth is also expected in the transportation equipment sector and to a much lesser extent in the construction industry. In construction, it is anticipated that growth will be principally outside the United States.

Despite the fact that existing high aluminum prices may induce the consumers to turn to alternative materials, prices for many of these substitutes has also risen sharply. For this reason a tight aluminum supply situation is expected to persist until at least 1990. Therefore, it is anticipated that aluminum prices will remain over US80¢/lb. in 1989.

In the longer term, the development of substantial new smelting capacity in Venezuela, Canada and the Middle East in particular, will result in some erosion of prices beginning in the early 1990s. It is expected that aluminum prices in the next decade will average between US65¢ and 75¢ (1988 constant U.S. cents).

Despite the fact that the input costs may continue to rise, it is anticipated that the newest smelters will have no difficulty in achieving satisfactory returns because of high operating efficiencies associated with recent improvements in smelting technology. Pechiney's 180 000 amp technology, which utilizes about 13 000 kWh of electricity to produce one tonne of metal, has been replaced with a 280 000 amp pot which achieves a 5% to 15% improvement in operating costs. Further improvements are expected with a new Pechiney technology that will reportedly operate at 300 000 amps.

With significant potential for the development of low cost electrical power generation capacity in a number of provinces, a favourable investment climate, a well trained labour force combined with geographical proximity and secure access to the large U.S. market, several additional new aluminum smelter projects are expected to be built in Canada in the next decade.

Item No.	Description	Canada			United States
		MFN	GPT	USA	Canada
76.01	Unwrought aluminum				
7601.10	- Aluminum, not alloyed				
7601.10.10	--- Billets, blocks, ingots, notched bars, pigs, slabs and wire bars	Free	Free	Free	Free
	--- Other:				
7601.10.91	---- Granules, cut from ingots, for use in the manufacture of cleaning compounds	1.98¢/kg	Free	Free	Free
7601.10.99	---- Other	10.3%	6.5%	Free	Free
7601.20	- Aluminum alloys				
7601.20.10	--- Billets, blocks, ingots, notched bars, pigs, slabs and wire bars	Free	Free	Free	Free
	--- Other:				
7601.20.91	---- Granules, cut from ingots, for use in the manufacture of cleaning compounds	1.98¢/kg	Free	Free	Free
7601.20.99	---- Other	10.3%	6.5%	Free	Free
7602.00.00	Aluminum waste and scrap	Free	Free	Free	Free
76.03	Aluminum powders and flakes	9.2% to 10.3%	Free to 6.5%	7.3% to 8.2%	3.1% to 4.5%
76.04	Aluminum bars, rods and profiles	2.1% to 10.3%	Free to 6.5%	1.6% to 8.2%	1.29% to 4%
76.05	Aluminum wire	2.1% to 10.3%	Free to 6.5%	1.6% to 8.2%	2% to 3.3%
76.06	Aluminum plates, sheets and strip, of a thickness exceeding 0.2 mm	Free to 10.3%	Free to 6.5%	Free to 9.2%	Free to 5.8%
76.07	Aluminum foil exceeding 0.2 mm	Free to 12.2%	Free to 8%	Free to 10.9%	2.7% to 5.2%
76.08	Aluminum tubes and pipes	8.1%	Free	6.4%	4.5%
76.09	Aluminum tube or pipe fittings	10.3%	6.5%	9.2%	5.1%
76.10	Aluminum structures (excluding prefabricated buildings of heading No. 94.06) and parts of structures, aluminum plates, rods, profiles, tubes and the like, prepared for use in structures	10.3%	6.5%	9.2%	5.1%

TARIFFS (cont'd)

Item No.	Description	Canada			United States
		MFN	GPT	USA	Canada
7611.00	Aluminum reservoirs, tanks, vats and similar containers	Free to 10.3%	Free to 6.5%	Free to 9.2%	2.3%
76.12	Aluminum casks, drums, cans, boxes and similar containers	10.3%	6.5%	9.2%	2.1% to 5.1%
7613.00.00	Aluminum containers for compressed or liquefied gas	10.3%	6.5%	9.2%	4.5%
76.14	Stranded wire, cables, plaited not electrically insulated	10.2%	6.5%	9.1%	4.4% to 5.1%
76.15	Table, kitchen or other household articles and parts thereof, of aluminum	10.2% to 11.4%	Free to 6.5%	9.1% to 10.2%	3.4% to 5.1%
76.16	Other articles of aluminum	Free to 10.3%	Free to 6.5%	Free to 9.2%	4.2% to 5.6%

Sources: Customs Tariffs, effective January 1989, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States (First Edition Supplement 2) effective January 1, 1989.

TABLE 1A. CANADA, ALUMINUM PRODUCTION AND TRADE, 1986-87

	1986		1987	
	(tonnes)	($000)	(tonnes)	($000)
Production	1 355 161	..	1 540 439	..
Imports				
Bauxite ore				
Guinea	314 924	14 590	493 096	19 150
Brazil	1 161 634	43 447	434 400	15 498
Guyana	236 734	13 436	363 431	14 893
Sierra Leone	241 065	7 806	346 519	10 186
United States	48 084	8 900	68 631	9 209
Australia	30 358	3 915	32 513	3 040
France	-	-	63 553	2 736
Turkey	-	-	34 955	2 128
Surinam	21 366	1 384	31 224	1 495
Malaysia	-	-	87 022	1 452
Greece	27 609	1 497	27 306	1 281
People's Republic of China	31 100	2 903	25 850	1 215
Jamaica	-	-	7 057	222
Denmark	-	-	2 000	126
Trinidad-Tobago	-	-	1 562	89
Total	2 112 874	97 879	2 019 119	82 721
Alumina				
Australia	501 905^{r}	98 758	892 742	171 128
Jamaica	618 202	124 447	503 329	91 991
United States	237 251	54 524	465 098	91 170
Ireland	-	-	135 272	28 726
Japan	268 912^{r}	57 162	58 677	18 105
Surinam	-	-	12 323	2 056
France	167	130	445	390
United Kingdom	7	4	267	148
West Germany	52 077	17 253	202	98
People's Republic of China	-	-	35	11
Venezuela	46 012	7 077	-	-
Netherlands	36	27	-	-
Total	1 724 569^{r}	359 382	2 068 390	403 823
Aluminum and aluminum alloy scrap	69 945^{r}	61 957^{r}	56 959	64 129
Aluminum paste and aluminum powder	1 722^{r}	8 036	2 362	11 190
Pigs, ingots, shot slabs, billets, blooms and extruded wire bars	64 459^{r}	120 322^{r}	53 479	102 130
Castings	1 354^{r}	13 670	1 418	15 028
Forgings	762	16 754	677	14 419
Bars and rods, n.e.s.	7 815^{r}	23 060	9 505	28 513
Plates	12 225^{r}	42 876	13 045	46 510
Sheet and strip up to .025 inch thick	35 261^{r}	101 417^{r}	51 446	145 817
Sheet and strip over .025 inch up to .051 inch thick	16 006^{r}	55 912^{r}	17 045	59 016
Sheet and strip over .051 inch up to .125 inch thick	51 489^{r}	122 938^{r}	56 532	141 081
Sheet over .125 inch thick	40 281^{r}	101 864^{r}	46 128	118 268
Foil or leaf	1 857^{r}	6 580^{r}	3 439	11 908
Converted aluminum foil	..	15 096	..	39 138
Structural shapes	5 456^{r}	23 578^{r}	7 243	33 259
Pipe and tubing	3 693^{r}	15 615	4 613	18 837
Wire and cable, not insulated	3 001	8 824	2 587	6 941
Aluminum and aluminum alloy fabricated materials, n.e.s.	..	103 960	..	115 843

TABLE 1A. (cont'd)

	1986		1987	
	(tonnes)	($000)	(tonnes)	($000)
Exports				
Pigs, ingots, shot slabs, etc.				
North America	856 976	1 540 771	859 253	1 714 677
Other Asia	208 463	331 037	216 819	403 057
Middle East	41 738	70 454	44 687	82 651
Western Europe	43 160	72 353	35 397	65 280
Central America	5 943	11 801	8 184	16 743
South America	2 667	5 268	5 720	11 920
Other Africa	4 757	8 986	1 780	3 789
Oceania	1	3	-	-
Total	1 163 705	2 040 673	1 171 840	2 298 117
Castings and forgings				
United States	10 986	94 592	10 373	91 681
Total	11 164^r	102 105	10 531	99 435
Bars, rods, plates, sheets and circles				
United States	51 852	133 267	81 732	200 755
Total	58 734^r	148 254	97 237	237 889
Foil or leaf				
United States	1 755	5 518	569	1 723
Total	1 845	5 885	573	1 739
Fabricated materials, n.e.s.				
United States	8 711	33 629	43 402	101 349
Total	10 703^r	42 131	46 575	114 491
Ores and concentrates				
United States	40 547	19 815^r	38 323	20 217
Total	45 295	23 100^r	45 620	25 140
Scrap				
United States	101 162^r	128 945	107 361	158 558
Total	123 608^r	155 365	126 923	187 979

Sources: Statistics Canada; Energy, Mines and Resources Canada.
^{r} Revised; .. Not available or not applicable; n.e.s. Not elsewhere specified; - Nil.
Note: Numbers may not add to totals due to rounding.

TABLE 1B. CANADA, ALUMINUM PRODUCTION AND TRADE, 1988P

Item No.		1988P	
		(tonnes)	($000)
Production		1 534 499	..
Imports		(Jan.-Sept.)	
2606.00.00	Aluminum ores [illegible] concentrates		
	Brazil	1 040 879	37 805
	United States	92 371	18 136
	Guinea	148 721	8 037
	Sierra Leone	191 699	6 805
	People's Republic of China	82 419	4 279
	Other countries	91 100	6 533
	Total	1 647 189	81 595
2620.40.00	Ash and residues containing mainly aluminum	1 608	1 616
2818.20.00	Aluminum oxide (excluding artificial corundum)		
	Australia	566 305	120 622
	Jamaica	386 223	98 726
	United States	277 191	65 322
	Ireland	55 630	13 564
	Japan	32 062	9 469
	France	1 908	1 782
	Austria	295	244
	Other countries	434	534
	Total	1 320 048	310 263
2818.30.00	Aluminum hydroxide	6 089	5 359
76.01	Unwrought aluminum		
7601.10	- Aluminum, not alloyed		
7601.10.10	--- Billets, blocks, ingots, notched bars, pigs, slabs and wire bars		
	United States	14 545	38 265
	Brazil	1 661	5 017
	Ghana	789	2 382
	South Africa	249	588
	Other countries	565	1 400
	Total	17 809	47 652
7601.10.91	---- Granules, cut from ingots, for use in the manufacture of cleaning compounds	22	59
7601.10.99	---- Other	1 107	5 214
7601.20	- Aluminum alloys		
7601.20.10	--- Billets, blocks, ingots, notched bars, pigs, slabs and wire bars		
	United States	23 891	55 132
	Brazil	798	2 418
	United Kingdom	266	1 366
	United Arab Emirates	195	375
	Other countries	425	1 354
	Total	25 575	60 645
7601.20.91	---- Granules, cut from ingots, for use in the manufacture of cleaning compounds	...	...

TABLE 1B. (cont'd)

Item No.		1988P Jan.-Sept.	
		(tonnes)	($000)
7601.20.99	---- Other	169	281
7602.00.00	Aluminum waste and scrap	49 553	69 891
76.03	Aluminum powders and flakes	2 179	5 965
76.04	Aluminum bars, rods and profiles		
7604.10	- Of aluminum, not alloyed		
	United States	5 009	19 627
	South Korea	240	772
	Other countries	468	1 909
	Total	5 717	22 308
	- Of aluminum alloys		
7604.21 to 7604.29	United States	5 064	22 214
	Other countries	812	3 329
	Total	5 876	25 543
76.05	Aluminum wire	3 443	11 634
76.06	Aluminum plates, sheets and strip, of a thickness exceeding 0.2 mm	77 879	597 970
76.07	Aluminum foil not exceeding 0.2 mm	28 199	83 274
76.08	Aluminum tubes and pipes	5 145	20 429
76.09	Aluminum tube or pipe fittings	..	7 490
76.10	Aluminum structures (excluding prefabricated buildings of heading No. 94.06) and parts of structures, aluminum plates, rods, profiles, tubes and the like, prepared for use in structures	..	30 697
76.11	Aluminum reservoirs, tanks, vats and similar containers	4 431	591
76.12	Aluminum casks, drums, cans, boxes and similar containers	43 529	15 574
76.13	Aluminum containers for compressed or liquefied gas	1 805	1 404
76.14	Stranded wire, cables, plaited bands and the like, of aluminum, not electrically insulated	462	731
76.15	Table, kitchen or other household articles and parts thereof, of aluminum	..	19 702
76.16	Other articles of aluminum	..	116 571
Exports			
2606.00	Aluminum ores and concentrates		
	United States	1 838	549
	West Germany	38	24
	Japan	17	13
	East Germany	19	11
	Total	1 912	598

TABLE 1B. (cont'd)

Item No.		1988P Jan.-Sept.	
		(tonnes)	($000)
2620.40	Ash and residues containing mainly aluminum	701	425
76.01	Unwrought aluminum		
7601.10	- Aluminum, not alloyed		
	United States	332 183	860 082
	Japan	46 670	97 385
	South Korea	22 932	63 621
	Netherlands	20 746	59 679
	Thailand	9 414	26 774
	Other countries	63 317	160 423
	Total	495 262	1 267 964
7601.20	- Aluminum alloys		
	United States	278 223	737 797
	Japan	43 965	113 859
	Netherlands	8 118	17 586
	Turkey	5 147	13 445
	Israel	4 223	11 715
	Portugal	3 188	8 766
	Other countries	23 508	62 038
	Total	366 372	965 206
7602.00	Aluminum waste and scrap		
	United States	106 254	188 130
	Japan	12 778	25 636
	United Kingdom	1 013	2 227
	Netherlands	809	2 013
	Other countries	2 560	3 837
	Total	123 414	221 843
76.03	Aluminum powders and flakes	221	701
76.04	Aluminum bars, rods and profiles	3 560	8 695
76.05	Aluminum wire	7 989	22 729
76.06	Aluminum plates, sheets and strip, of a thickness exceeding 0.2 mm	82 837	230 457
76.07	Aluminum foil not exceeding 0.2 mm	7 066	21 150
76.08	Aluminum tubes and pipes	869	3 389
7609.00	Aluminum tube of pipe fittings	..	1 676
76.10	Aluminum structures (excluding prefabricated buildings of heading No. 94.06) and parts of structures, aluminum plates, rods, profiles, tubes and the like, prepared for use in structures	..	32 064
7611.00	Aluminum reservoirs, tanks, vats and similar containers	65	1 091
76.12	Aluminum casks, drums, cans, boxes and similar containers	81 102	13 834

TABLE 1B. (cont'd)

Item No.		1988P Jan.-Sept.	
		(tonnes)	($000)
7613.00	Aluminum containers for compressed or liquefied gas	1 391	1 155
76.14	Stranded wire, cables, plaited bands and the like, of aluminum, not electrically insulated	5 728	16 934
76.15	Table, kitchen or other household articles and parts thereof, of aluminum	..	1 370
76.16	Other articles of aluminum	..	68 026

Sources: Energy, Mines and Resources Canada; Statistics Canada.
P Preliminary; .. Not available or not applicable; ... Amount too small to be expressed.

TABLE 2. CANADA, ALUMINUM SMELTER CAPACITY

(as of December 31, 1988)

	Annual tonnes
Alcan Aluminium Limited	
Quebec	
Grande Baie	171 000
Jonquière	432 000
Isle-Maligne	73 000
Shawinigan	84 000
Beauharnois	47 000
British Columbia	
Kitimat	268 000
Total Alcan capacity	1 075 000
Canadian Reynolds Metals Company, Limited	
Quebec	
Baie Comeau	272 000
Aluminerie de Bécancour Inc.	
Quebec	
Bécancour	240 000
Total Canadian capacity	1 587 000

Source: Compiled from company reports by Energy, Mines and Resources Canada.

TABLE 3. CANADA, CONSUMPTION[1] OF ALUMINUM METAL AT FIRST PROCESSING STAGE, 1985-87

	1985	1986	1987P
		(tonnes)	
Castings			
Sand	1 640	2 000	2 168
Permanent mould	16 180	16 306	19 799
Die and other	31 368	35 122	36 059
Total	49 188	53 428	58 026
Wrought products			
Extrusions, including tubing	91 675^{r}	114 374	110 174
Sheet, plate, coil and foil	130 522	153 201	170 949
Other wrought products (including rod, forgings and slugs)	57 286	52 219	56 157
Total	279 483^{r}	319 794	337 280
Other uses			
Destructive uses (deoxidizer), non-aluminum base alloys, powder and paste and other uses	17 362^{r}	20 048	26 086
Total consumed	346 033	393 270	421 392
Secondary aluminum[2]	78 047	58 338	67 838

	Metal Entering Plant			On Hand December 31		
	1985	1986	1987P	1985	1986	1987P
Primary aluminum ingot and alloys	314 614	339 084	371 604	23 050	19 440	20 048
Secondary aluminum	51 439	46 628	45 691	4 017	2 649	3 149
Scrap originating outside plant	89 969	86 994	99 181	6 126	6 858	6 957
Total	456 022	472 706	516 476	33 193	28 947	30 154
Aluminum shipments[3]				30 041	25 344	26 039

[1] Available data as reported by consumers. [2] Aluminum metal used in the production of secondary aluminum is not included in consumption totals. [3] Aluminum metal shipped without change. Does not refer to shipments of goods of own manufacture.

Note: Revisions reflect changes to company specific data.

P Preliminary; ^{r} Revised.

TABLE 4. AVERAGE PRICES

Year	Month	LME Cash[1]	LME 3-month[1]	LME Cash[2]	M.W. U.S. Market[1]
			(US¢/lb.)		
1979	Average	n.a.	n.a.	72.7	70.7
1980	Average	n.a.	n.a.	80.7	76.1
1981	Average	n.a.	n.a.	57.3	59.8
1982	Average	n.a.	n.a.	45.0	46.8
1983	Average	n.a.	n.a.	65.3	68.3
1984	Average	n.a.	n.a.	56.5	61.1
1985	Average	n.a.	n.a.	47.9	48.8
1986	Average	n.a.	n.a.	52.2	55.9
1987	January	n.a.	n.a.	53.1	54.6
	February	n.a.	n.a.	58.2	59.4
	March	n.a.	n.a.	62.0	62.5
	April	n.a.	n.a.	63.5	65.0
	May	n.a.	n.a.	64.0	68.9
	June	n.a.	70.9	66.8	72.5
	July	n.a.	73.5	75.0	74.2
	August	n.a.	77.4	82.1	81.7
	September	80.7	77.4	79.2	80.7
	October	89.1	83.5	89.0	84.4
	November	76.7	74.9	76.2	80.2
	December	83.3	80.3	82.7	83.4
1988	January	91.2	86.0	90.8	89.7
	February	98.2	91.4	97.0	96.3
	March	114.6	103.5	114.6	107.1
	April	113.8	101.6	113.8	107.1
	May	137.0	109.5	135.5	114.5
	June	164.8	129.5	162.3	126.3
	July	122.6	118.2	117.1	122.3
	August	125.2	122.6	122.5	124.4
	September	109.8	108.5	108.3	111.4
	October	106.5	101.5	104.8	104.7
	November	110.4	106.0	108.0	107.4
	December	113.5	109.7	n.a.	110.0

Source: "Metals Week".

[1] High grade 99.7% purity. [2] Standard grade 99.5% purity.

n.a. Not applicable as contracts not traded.

TABLE 5. WORLD MINE PRODUCTION OF BAUXITE

	1984	1985	1986	1987
	(000 tonnes)			
Europe				
France	1 529.5	1 529.6	1 379.0	1 388.2
Greece	2 293.8	2 453.8	2 231.4	2 472.0
Italy	-	-	-	16.6
Spain	7.3	2.4	3.0	-
Yugoslavia	3 347.0	3 538.0	3 459.0	3 394.0
Total	7 177.6	7 523.8	7 072.4	7 270.8
Africa				
Ghana	49.0	169.5	204.0	196.2
Guinea	14 738.0	13 956.0	14 656.0	16 282.0
Mozambique	-	5.0	4.0	5.0
Sierra Leone	1 041.2	1 184.5	1 242.0	1 391.0
Zimbabwe	23.0	21.0	24.3	25.0
Total	15 851.2	15 336.0	16 309.2	17 899.2
Asia				
India	2 078.0	2 340.7	2 662.2	2 779.0
Indonesia	1 003.0	830.5	649.9	635.3
Malaysia	680.4	491.9	566.2	482.1
Pakistan	3.0	2.0	3.0	4.0
Turkey	131.6	213.8	280.4	246.5
Total	3 896.0	3 878.9	4 161.7	4 146.9
Americas				
United States	856.0	674.0	510.0	576.0
Brazil	6 433.1	5 846.0	6 446.3	6 566.5
Guyana	2 485.0	2 206.0	2 600.0	278.5
Jamaica	8 735.0	6 239.0	6 964.0	7 660.0
Surinam	3 374.9	3 738.3	3 730.6	2 581.1
Colombia	-	-	-	217.0
Total	21 884.0	18 703.3	20 250.9	20 385.6
Australasia				
Australia	31 537.0	31 839.0	32 432.0	34 206.0
Eastern countries				
China	230.0	2 630.0	2 650.0	2 750.0
Hungary	2 993.6	2 814.8	3 022.3	3 101.1
Romania	460.0	460.0	500.0	480.0
U.S.S.R.	6 200.0	6 400.0	6 275.0	4 850.0
Total	11 953.6	12 304.8	12 447.3	11 181.1
World Total	92 299.4	89 585.8	92 625.5	95 089.6

Source: EMR.
- Nil.

TABLE 6. WORLD PRODUCTION OF ALUMINA

	1984	1985	1986	1987
	(000 tonnes)			
Europe				
France	1 031.0	877.0	884.0	866.0
Germany F.R.	1 701.0	1 657.0	1 560.0	1 313.0
Greece	482.0	402.0	458.0	529.0
Ireland	650.0	557.0	685.0	787.0
Italy	625.0	555.0	618.0	700.0
Spain	742.0	729.0	748.0	801.0
United Kingdom	106.0	108.0	108.0	110.0
Yugoslavia	1 135.0	1 138.0	1 117.0	1 112.0
Total	6 472.0	6 023.0	6 178.0	6 218.0
Africa				
Guinea	535.0	565.0	572.0	542.0
Asia				
India	569.0	571.0	586.0	650.0
Japan	1 519.0	1 336.0	986.0	711.0
Taiwan	-	-	-	-
Turkey	75.0	113.0	142.0	95.0
Total	2 163.0	2 020.0	1 714.0	1 456.0
Americas				
Brazil	882.0	1 096.0	1 258.0	1 396.0
Canada	1 126.0	1 019.0	1 015.0	952.0
Guyana	-	-	-	-
Jamaica	1 713.0	1 622.0	1 586.0	1 572.0
Surinam	1 237.0	1 242.0	1 471.0	1 363.0
United States	4 545.0	3 465.0	3 105.0	4 150.0
Venezuela	1 139.0	1 135.0	1 269.0	1 360.0
Total	10 652.0	9 579.0	9 704.0	10 792.0
Australia	8 781.0	8 792.0	9 423.0	10 109.0
Eastern				
Czechoslovakia	85.0	75.0	70.0	75.0
Germany D.R.	43.0	43.0r	46.0	46.0
Hungary	846.0	798.0	856.0	858.0
Romania	552.0	548.0	555.0	540.0
U.S.S.R.	4 200.0	4 350.0	4 500.0	4 580.0
China P.R.	960.0	1 020.0	1 060.0	1 215.0
Total	6 686.0	6 834.0	7 087.0	7 314.0
World Total	35 279.0	33 813.0	34 678.0	36 432.0

Source: EMR.
- Nil; r Revised.

TABLE 7. WORLD PRODUCTION OF ALUMINUM

	1984	1985	1986	1987
	(000 tonnes)			
Europe				
France	341.5	293.2	321.8	322.5
Germany, F.R.	777.2	745.4	763.7	737.7
Italy	230.2	224.1	242.6	232.6
Netherlands	247.3	243.9	258.0	268.7
Norway	760.8	724.1	729.1	797.8
Spain	380.8	370.1	354.7	341.0
United Kingdom	287.9	275.4	275.9	294.4
Yugoslavia	267.5	314.1	273.2	293.9
Other	476.5	450.6	454.6	459.0
Total	3 769.7	3 640.9	3 673.6	3 747.6
Africa				
Total	413.0	473.2	552.2	571.6
Asia				
Bahrain	177.3	174.8	178.2	180.3
India	267.9	266.5	257.1	265.3
Indonesia	199.0	216.8	218.8	201.4
Japan	286.7	226.5	140.2	40.6
Dubai	155.4	153.2	154.8	155.9
Other	97.5	114.6	117.3	103.7
Total	1 183.8	1 152.4	1 066.4	947.2
America				
Canada	1 222.0	1 282.3	1 355.2	1 540.4
United States	4 099.0	3 499.7	3 037.0	3 343.0
Brazil	455.0	549.4	757.4	843.5
Venezuela	386.0	402.5	423.3	439.6
Other	204.8	211.4	216.3	217.2
Total	6 366.8	5 944.9	5 789.2	6 383.7
Australasia				
Australia	754.8	851.7	876.8	1 024.2
New Zealand	242.9	243.5	236.2	252.0
Total	997.7	1 095.2	1 113.0	1 276.2
Eastern countries				
Romania	244.0	265.0	269.0	260.0
U.S.S.R.	2 300.0	2 300.0	2 350.0	2 370.0
China P.R.	219.7	222.6	225.5	225.4
Other	450.0	480.0	510.0	540.0
Total	3 213.7	3 267.6	3 354.5	3 395.4
World Total	**15 944.7**	**15 574.2**	**15 548.9**	**16 321.7**

Source: EMR.

TABLE 8. WORLD CONSUMPTION OF ALUMINUM

	1984	1985	1986	1987
			(000 tonnes)	
Europe				
Belgium/Luxembourg	289.4	267.7	273.3	284.7
France	579.3	586.1	592.6	615.6
Germany, F.R.	1 151.6	1 160.9	1 186.7	1 185.7
Italy	448.0	470.0	510.0	548.0
Spain	191.4	211.0	244.0	259.2
United Kingdom	369.5	351.3	389.1	383.6
Yugoslavia	159.6	168.2	163.0	168.8
Other Europe	742.0	746.6	802.0	775.7
Total	3 930.8	3 961.8	4 160.7	4 221.3
Africas				
Total	202.8	210.4	200.4	231.3
Asia				
India	310.0	297.6	310.0	326.0
Japan	1 696.0	1 685.0	1 700.0	1 750.0
Other Asia	647.5	743.8	860.4	996.6
Total	2 653.5	2 726.4	2 870.4	3 072.6
Americas				
Canada	336.0	345.0	321.0	421.6
United States	4 457.0	4 282.0	4 316.0	4 536.0
Brazil	294.8	347.5	423.7	430.3
Other America	352.8	360.0	374.0	408.7
Total	5 440.6	5 334.5	5 434.7	5 796.6
Oceania				
Total	294.7	318.2	325.1	346.0
Eastern countries				
German D.R.	218.0	230.0	227.0	222.0
Hungary	192.8	199.5	209.4	197.9
U.S.S.R.	1 750.0	1 750.0	1 700.0	1 800.0
China P.R.	630.0	700.0	750.0	800.0
Other	481.9	478.0	481.6	473.9
Total	3 272.7	3 357.5	3 368.0	3 493.8
World Total	**15 795.1**	**15 908.8**	**16 359.3**	**17 161.6**

Source: EMR.

Antimony

H.L. MARTIN

North America's sole antimony mine, the Durham mine of Dominion Explorers Inc., is located at Lake George, New Brunswick. In 1987, the company reported a record production of 4 384 t of clean high-grade sulphide concentrates, containing an estimated 2 850 t of antimony. Revenue of C$8 million reported for 1987 all came from export sales to European smelters. The mine's output accounted for almost 10% of the western world's mine production of 30 117 t as reported by the World Bureau of Metal Statistics. Production at the Durham mine in 1988 is estimated to have almost equalled the 1987 record level.

In Canada, antimony is also associated with lead ores; it is produced in the form of antimonial lead at Cominco Ltd.'s lead smelter in Trail, British Columbia, and as antimony slag at the lead smelter of Brunswick Mining and Smelting Corporation Limited at Belledune, New Brunswick. In 1988, these two plants produced an estimated 437 t of contained antimony in the two forms, down from 485 t reported in 1987.

Canada's total shipments of antimony produced from domestic sources, plus the paid-for content of concentrates shipped for export, amounted to an estimated 2 977 t in 1988, compared to 3 706 t in 1987, valued at $8.4 million and $9.7 million, respectively.

In November 1988, Amspec Chemical Corp. of New Jersey announced plans to establish a 3 600 t/y antimony trioxide plant near Chatham, New Brunswick. Scheduled to come on-stream in mid-1989, Amspec's new operation, to be called Apocan (Antimony Products of Canada), will employ 25-30 people. Apocan is taking over the former Enhanced Recovery Systems Ltd.'s facilities, and will spend about US$8.3 million for capital expenditures and working capital. The first phase calls for the installation of a reverberatory furnace to convert antimony metal, imported from the People's Republic of China, into the trioxide form. In the second phase, Apocan would install a rotary kiln to roast sulphide concentrates.

Antimony prices were on a downward trend in 1988. The monthly average Metals Week New York dealer price declined from US$1.13/lb. in January 1988 to US$0.97 by mid-year; it recovered to US$1.05/lb. by September before again declining to a low of US$0.95 in December. The average price in 1988 was US$1.04/lb., down 6% from the 1987 average of US$1.11/lb. European Free Market prices, as reported by Metal Bulletin for antimony metal, fell from US$2310-2350/t in December 1987 to US$1925-2025/t in December 1988. The price decline reflects an apparent oversupply situation for antimony metal and antimony trioxide as a result of increased exports from the People's Republic of China. Moreover, during 1988, the People's Republic of China was reported to be selling antimony trioxide at 30% below the prevailing market price in the United States and Europe. A complaint of "dumping" against the People's Republic of China was filed with the EEC.

World production of primary antimony in 1987, as estimated by the U.S. Bureau of Mines, totalled 61,875 short tons. The People's Republic of China is by far the world's largest producer, followed by the U.S.S.R., Bolivia, the Republic of South Africa and Canada. Recyling of secondary antimony, mainly from battery scrap, forms an important part of the total annual supply of antimony in most industrialized countries, though such statistics are generally lacking. The United States does report such production; for 1988, the U.S. Bureau of Mines estimated secondary production at 18,000 short tons, almost 40% of U.S. apparent consumption of 46,000 short tons of antimony.

The largest source of secondary antimony is battery scrap, though in the United States and Canada, battery improvements are impacting on the amount of antimony used per battery, and consequently, the amount of secondary metal available for recycling. However, maintenance-free batteries have not made the same inroads

---

H.L. Martin is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 992-3731.

outside North America, therefore significantly more antimony is available from battery scrap in other countries.

The storage battery industry remains the major market for metallic antimony, with lesser amounts used for bearing metals, cable sheathing, type metal, lead pipe and sheet, soldering and plating. However, technological developments are gradually reducing the quantities of antimony consumed in these products. A prime example is the maintenance-free battery, which can be produced by either reducing the antimony content or by replacing the antimony with calcium. In other metallic applications, substitution of antimony by plastic materials is making important inroads.

On the other hand, unlike metallic end-uses the demand for antimony compounds is growing strongly, especially for antimony oxides. The largest end-use is for flame retardants, primarily for plastic materials, which now accounts for about two-thirds of the primary antimony consumed in the United States. Increasingly stringent fire standards, particularly for products manufactured by the automotive, construction and furniture sectors, are likely to continue to provide substantial opportunities for growth in demand for flame retardants.

Other applications for antimony compounds include pigments, catalysts, tracer ammunition and explosion primers, paints and vulcanizing of rubber. Unlike antimony consumption in metallic products, antimony compounds are dissipated in their usage and cannot be recycled. Increased consumption of antimony compounds will therefore not lead to any increase in the amount of antimony available from scrap, thus strengthening the demand for primary antimony.

TARIFFS

Item No.	Description	Canada			United States	EEC
		MFN	GPT	USA	Canada	MFN
2617.10.00	Antimony ores and concentrates	Free	Free	Free	Free	Free
2825.80.00	Antimony oxides	Free	Free	Free	Free	11%
8110.00	Antimony and articles thereof, including waste and scrap					
8110.00.10	--- Unwrought antimony; not alloyed; powders, not alloyed	4%	Free	3.2%	Free	Free
8110.00.20	--- Unwrought antimony, alloyed; waste and scrap; powders, alloyed; articles of antimony	10.2%	6.5%	8.1%	Free	Free to 8%

Sources: Customs Tariffs, effective January 1989, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States (First Edition Supplement 2) effective January 1, 1989; Official Journal of the European Communities, Vol. 30, No. L256, 1987, "Conventional" column.

TABLE 1A. CANADA, ANTIMONY PRODUCTION AND IMPORTS, 1986 AND 1987 AND CONSUMPTION, 1986 AND 1987

	1986		1987	
	(tonnes)	($000)	(tonnes)	($000)
Production				
New Brunswick	3 258	8 982	3 248	8 220
British Columbia	489	2 993	374	1 209
Northwest Territories	24	147	44	141
Yukon	32	195	40	129
Manitoba	1	9	...	...
Ontario	1	6	...	...
Total	3 805	12 332	3 706	9 698
Imports				
Antimony oxide				
United Kingdom	481	2 149	809	3 432
United States	699	2 730	551	2 148
Belgium-Luxembourg	78	355	96	449
France	20	85	70	291
Total	1 278	5 318	1 526	6 320
Antimony, primary forms and fabricated materials				
United States	199	756	171	540
People's Republic of China	38	152	20	65
West Germany	-	-	18	63
France	4	10	-	-
Total	241	918	209	668

	1986	1987P
	(kilograms)	
Consumption[1],[2]		
Antimony metal used for, or in the production of:		
Antimonial lead	479 541	461 044
Babbitt	11 363	9 235
Other uses[3]	48 751	69 868
Total	539 655	540 147
Held by consumers on December 31[2]	28 422	21 172

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Antimony content of primary and secondary antimonial-lead alloys. [2] Available data, as reported by consumers. [3] Includes solder, type metal, and miscellaneous uses.
P Preliminary; - Nil; ... Amount too small to be expressed.
Note: Numbers may not add to totals due to rounding.

TABLE 1B. CANADA, ANTIMONY PRODUCTION AND IMPORTS, 1988

Item No.		1988P	
		(tonnes)	($000)
Production			
New Brunswick		2 576	7 276
British Columbia		346	976
Northwest Territories		43	123
Ontario		8	22
Yukon		5	14
Total		2 977	8 411
Imports		(Jan.-Sept.)	
2617.10	Antimony ores and concentrates		
	United States	60	146
	People's Republic of China	47	143
	Total	107	289
2825.80	Antimony oxides		
	United States	623	2 181
	United Kingdom	433	2 064
	France	141	520
	Belgium	102	466
	Total	1 307	5 232
2918.13.10.10	Antimony potassium tartrates		
	Japan	4	11
	United States	3	5
	Other countries	2	4
	Total	9	20
8110.00	Antimony and articles thereof, including waste and scrap		
8110.00.10	-- Unwrought antimony, not alloyed; powders, not alloyed		
	People's Republic of China	37	138
	United States	32	94
	Total	69	233
8110.00.20	--- Unwrought antimony, alloyed; waste and scrap; powders, alloyed; articles of antimony		
8110.00.20.10	----- Unwrought antimony; powders; articles of antimony		
	United States	22	57
	Other countries	...	1
	Total	22	58
8110.00.20.20	----- Waste and scrap		
	Zaire	1	10
	People's Republic of China	1	8
	United States	1	...
	Total	3	18
Exports			
2617.10	Antimony ores and concentrates		
	Total	2 346	4 170

TABLE 1B. (cont'd)

Item No.		1988P Jan.-Sept.	
		(tonnes)	($000)
Exports (cont'd)			
2825.80	Antimony oxides		
	United States	23	24
	Total	23	24
8110.00	Antimony and articles thereof, including waste and scrap		
	United States	..	338
	United Kingdom	..	2
	Total	..	341

Sources: Statistics Canada; Energy, Mines and Resources, Canada.
P Preliminary; .. Not available; ... Amount too small to be expressed.
Note: Numbers may not add to totals due to rounding.

TABLE 2. CANADA, CONSUMPTION AND CONSUMERS' STOCKS OF ANTIMONY[1], 1975, AND 1980-87

	Consumption		On hand at end of year	
	Antimony metal	Antimonial-lead alloy[2]	Antimony metal	Antimonial-lead alloy[2]
	(kilograms)			
1975	454 164	723 155	116 760	170 478
1980	369 732	643 983	42 389	51 405
1981	209 829	691 180	35 105	151 400
1982	161 034	605 502	39 799	76 979
1983	169 648r	560 705	24 381r	130 104
1984	342 705r	648 413	33 524r	23 319
1985	184 993r	826 846	24 512	20 298
1986	539 655	759 876	28 422	104 360
1987P	540 147	692 750	21 172	164 782

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Available data, as reported by consumers. [2] Antimony content of primary and secondary antimonial-lead alloys.
P Preliminary; r Revised.

TABLE 3. WORLD MINE PRODUCTION OF ANTIMONY, 1985-87

	1985	1986	1987
	(tonnes)		
Europe	**2 310**	**1 696**	**1 280**
Austria	477	514	355
Italy	495	278	91
Spain	250	45	-
Yugoslavia	1 086	859	834
Africa	**8 297**	**8 074**	**6 919**
Morocco	787	928	467
South Africa	7 390	7 024	6 299
Zimbabwe	120	122	153
Asia	**3 318**	**3 476**	**2 335**
Malaysia	27	-	22
Pakistan	5	-	11
Thailand	1 808	1 486	962
Turkey	1 478	1 990	1 340
America	**15 628**	**19 428**	**18 483**
Bolivia	8 925	10 243	10 635
Canada	1 075	3 805	3 575
Guatemala	90	1 649	1 405
Honduras	320	-	-
Mexico	4 266	3 337	2 839
Peru	452	194	29
United States	500	200	-
Oceania			
Australia	1 458	1 064	1 100
Total	31 011	33 738	30 117
Other			
China, P.R.	13 500	14 000	29 573[1]
Czechoslovakia	900	1 000	..
U.S.S.R.	6 500	6 000	..
Other	700	700	..

Source: World Metal Statistics.

[1] Exports only.

- Nil; .. Not available.

TABLE 4. REPORTED INDUSTRIAL CONSUMPTION OF PRIMARY ANTIMONY IN THE UNITED STATES, BY PRODUCT, 1986 AND 1987

	1986	1987
	(tonnes of antimony content)	
Metal Products		
Ammunition	W	372
Antimonial lead	551	664
Bearing metal and bearings	139	187
Cable covering	62	W
Castings	11	8
Collapsible tubes and foil	W	W
Sheet and pipe	36	76
Solder	252	347
Type metal	8	8
Other	379	750
Nonmetal Products		
Ammunition primers	21	53
Fireworks	4	3
Flame-retardants	6 245	5 609
Ceramics and glass	931	1 122
Pigments	227	278
Plastics	884	750
Rubber products	37	W
Other	147	200
Total	9 934	10 055

Source: U.S. Bureau of Mines.

W - Withheld; included with "other".

TABLE 5. ANTIMONY PRICES, NEW YORK DEALER[1]

	1986	1987	1988
		(US$/lb.)	
January	1.31	1.03	1.13
February	1.32	1.05	1.13
March	1.33	1.11	1.09
April	1.35	1.12	1.08
May	1.34	1.18	1.08
June	1.27	1.17	0.97
July	1.08	1.09	0.97
August	1.07	1.07	1.01
September	1.10	1.12	1.05
October	1.19	1.10	1.05
November	1.16	1.09	0.95
December	1.11	1.12	0.95
	1.22	1.11	1.04

Source: Metals Week.

[1] 99.5 - 99.6% metal, c.i.f. U.S. ports, 5 ton lots, duty paid.

Asbestos

W.M. HOSKIN

For the first time since 1979 the asbestos commodity news is good: Canadian production increased 6% in 1988 over 1987 with all 1988 production sold; mines are operating at essentially 100% capacity; and prices, especially for short fibre started slowly but surely to firm. Total shipments in 1988 were 705 000 t valued at $268 million compared to 665 000 t valued at $238 million in 1987 according to preliminary and revised figures.

Exports exceeded production in 1988 as inventory was being sold. In fact, in the first nine months of 1988 exports amounted to 617 724 t valued at $287 million compared to 477 000 t valued at $266 million during the same period in 1987.

Employment in the asbestos mining sector fluctuated throughout 1988 due to a strike at Lac d'amiante du Québec from May 23 to the end of June, involving 425 workers (settled by conciliation), and closure of the Bell Mine on March 5. Although this closure was expected to be for an indeterminate period of time, due to growing demand and firming prices officials announced that the mine would reopen. Development work at the Bell Mine started on October 17, 1988 with 300 workers being recalled. Full operations are expected to resume at the end of January, 1989. Baie Verte Mines Inc. (BVM) laid-off 100 workers at the end of August, 1988 as it neared the end of the accelerated waste removal program.

CANADIAN DEVELOPMENTS

BVM started construction of a wet-milling plant based on a patented process purchased from Mineral Commodities Limited of Australia. Wet processing permits secondary recovery of short asbestos fibres from tailings. As BVM is nearing exhaustion of its reserves, this new process is expected to extend the life of BVM by approximately 13 years. For this new technological development BVM received: from the Atlantic Canada Opportunities Agency (ACOA) a $6.3 million grant, $740 000 for an interest buy-down, and $4.4 million in loan insurance; and from the Newfoundland government a $2 million loan guarantee. As of December 29, 1988, Cliff Resources Corporation, a Toronto based publicly traded company, acquired controlling interest in BVM.

Cassiar Mining Corporation negotiated a $25 million development loan from the British Columbia government to assist in its $43 million development of the underground McDame deposit. Development work started in 1988 and is progressing well. The McDame reserves will extend the life of the mine by at least 10 years; the currently excavated pit will be exhausted by 1991. Cassiar also has a wet-process operation, now at the pilot plant stage. This wet-milling process was developed by the Government of Canada (CANMET) with the transfer of technology and early development accomplished via an NRC Programme for Industry-Laboratory Projects grant of $750 000. The pilot plant stage was assisted by an EMR Industry Energy Research and Development grant of $1.5 million.

J M Asbestos Inc. had a very successful, relatively uneventful year with its mine operating at full capacity in terms of available ore.

REGULATORY DEVELOPMENTS

With respect to regulatory developments, 1988 was a full year. In order for Canada to be able to ratify the International Labour Organization Convention 162 on Safety in the Use of Asbestos, Canada made amendments affecting asbestos under the Hazardous Products Act. Spray application of asbestos, except for particular mixtures in which the asbestos fibres are encapsulated with a binder during spraying, are prohibited. A second amendment severely restricted the advertising, sale and importation into Canada of products containing

---

W.M. Hoskin is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 992-4828.

crocidolite (blue) asbestos. Further, all the provinces and territories officially agreed to Canada's planned ratification and agreed to implement the provisions of the Convention in their respective jurisdictions. Hence, Canada ratified this Convention on June 16, 1988. As Canada was the second country to ratify the Convention, it will come into force as an international instrument on June 16, 1989. Canada is actively encouraging other countries to ratify (an action also taken by Sweden and Finland) and implement the terms of this Convention, as widespread acceptance will benefit workers and industry worldwide.

The U.S. Environmental Protection Agency (EPA) continued to work on its 1986 proposed asbestos rule by issuing four major support documents on April 1, 1988 (exposure assessment, non-occupational exposure, modelling study and regulatory impact analysis), and four other studies on May 4 (health hazard of non-asbestos fibres, recent epidemiology, durable fibre exposure and industry profile). However, EPA's scientific case remains at odds with world scientific opinion. Canada and others submitted written comments on continuing deficiencies, and even after cross-examination hearings on the new documents were held in Washington in September, the EPA appears intransigent on the crucial issues of fibre distinction, fibre potency and associated risk. A decision/rule is expected from the EPA during 1989.

The European Economic Community (EEC) is in the process of harmonizing its regulations for "Europe 1992". Although the EEC has implemented the "controlled-use" philosophy in its regulations of asbestos, there remain strong anti-asbestos forces in some countries. Denmark has banned the use of asbestos in brake linings due to the risk asbestos might create for maintenance mechanics. This has created an obstacle to the free exchange of goods and services within the Community (reference to Directive 71/320/EEC). The Commission has challenged Denmark in the European Court of Justice, and an action via the GATT has been started. Germany wants to reclassify asbestos from a Class II to a Class I carcinogen. Since a Class I classification calls for zero exposure, this action amounts to a "de facto" ban.

ALTERNATE FIBRES AND MATERIALS

There are growing concerns about the possible health effects of man made mineral fibres and other natural fibres. The International Programme on Chemical Safety, a Division of the World Health Organization's Environmental Health Section, has recommended further study on several areas including: the significance of the physical and chemical properties of asbestos and other mineral fibres; on the biological significance of the durability of mineral fibres in the body; and immunological, cellular and biochemical responses to natural mineral fibres. In a related but different area, it has been reported that the Danish Labour Inspectorate, following a European survey of 22 000 workers in the mineral fibre industry over the half century to 1982 indicated a 25% higher than normal lung cancer mortality rate, is expected to place several widely used non-asbestos insulating fibre materials on its carcinogenic substances list.

OUTLOOK

Continuing strong demand, particularly for short grades, and firming prices are expected to continue through 1989 and probably into 1990. Canadian mine production has broken through the 700 000 t mark. With the reopening of the Bell Mine in 1989 and the additional short fibre production from wet processing operations - barring any very negative regulatory developments - asbestos fibre production can be expected to rise steadily over the next five years.

TARIFFS

Item No.	Description	Canada MFN	Canada GPT	Canada USA	United States Canada
2524.00	Asbestos				
2524.00.10	--- Crude	Free	Free	Free	Free
2524.00.90	--- Other	8%	5%	Free	Free
68.11	Articles of asbestos-cement, of cellulose fibre-cement or the like				
6811.10.00	- Corrugated sheets	8%	5%	6.4%	Free
6811.20.00	- Other sheets, panels, tiles and similar articles	8%	5%	6.4%	Free
6811.30.00	- Tubes, pipes and tube or pipe fittings	8%	5%	6.4%	Free
6811.90.00	- Other articles	8%	5%	6.4%	Free
68.12	Fabricated asbestos fibres; mixtures with a basis of asbestos or with a basis of asbestos and magnesium carbonate; articles of such mixtures or of asbestos				
6812.10.00	- Fabricated asbestos fibres; mixtures with a basis of asbestos or with a basis of asbestos and magnesium carbonate	8%	5%	6.4%	Free
6812.20.00	- Yarn and thread	12.5%	12.5%	10%	Free
6812.30.00	- Cords and string, whether or not plaited	12.5%	12.5%	10%	Free
6812.40.00	- Woven or knitted fabric	25%	25%	20%	Free
6812.50.00	- Clothing, clothing accessories, footwear and headgear	25%	25%	20%	2.4% to 10%
6812.60.00	- Paper, millboard and felt	8%	5%	6.4%	Free
6812.70.00	- Compressed asbestos fibre jointing, in sheets or rolls	8%	5%	6.4%	Free
6812.90	- Other				
6812.90.10	--- Belting	17.5%	7.5%	14%	Free
68.13	Friction material and articles thereof, not mounted for brakes, for clutches or the like, with a basis of asbestos, of other mineral substances or of cellulose				
6813.10	- Brake linings and pads				
6813.10.10	--- For motor vehicles of heading No. 87.02, 87.03, 87.04 or 87.05	11.3%	Free	10.1%	Free
6813.10.90	--- Other	8%	5%	7.2%	Free

Sources: Customs Tariffs, effective January 1989, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States (First Edition Supplement 2) effective January 1, 1989.

TABLE 1A. CANADA, ASBESTOS PRODUCTION AND TRADE, 1986 AND 1987

	1986		1987	
	(tonnes)	($000)	(tonnes)	($000)
Production (shipments)[1]				
By type				
Group 3, spinning	10 409	9 850	9 938	9 269
Group 4, shingle	194 511	107 748	216 577	112 459
Group 5, paper	127 172	51 004	138 629	54 628
Group 6, stucco	155 537	41 116	159 433	40 650
Group 7, refuse	174 752	24 335	139 969	20 984
Total	662 381	234 053	664 546	237 990
By province				
Quebec	540 733	178 036	x	x
British Columbia	78 348	39 663	x	x
Newfoundland	43 300	16 354	x	x
Total	662 381	234 053	664 546	237 990
Exports				
Crude (unspecified)				
India	-	-	1 696	932
Italy	108	59	-	-
United States	19	15	-	-
Total	127	74	1 696	932
Milled fibre (groups 3, 4 and 5)				
Japan	34 751	25 032	27 853	20 819
France	28 535	19 753	26 896	19 279
Italy	25 308	21 216	25 411	19 209
United States	22 427	19 205	20 156	16 457
West Germany	31 681	26 202	21 381	16 126
Algeria	21 438	20 693	16 074	14 356
Thailand	16 542	10 592	24 268	14 299
Mexico	9 845	7 798	13 515	11 632
India	22 811r	15 005r	16 837	11 126
Spain	13 814	8 265	14 331	10 499
United Kingdom	15 428	13 706	11 253	9 334
Belgium-Luxembourg	6 463	5 460	9 086	7 808
Austria	10 339	8 215	10 291	7 408
Malaysia	5 140	4 050	9 442	6 272
Other countries	111 426	92 932	106 527	87 568
Total	375 948r	298 124r	353 321	272 192
Shorts (groups 6 to 9)				
Japan	78 907	25 201	59 468	19 700
United States	90 517r	19 276r	63 929	12 823
South Korea	24 091	7 504	24 281	8 468
India	16 044r	6 546r	13 664	5 703
Taiwan	17 251	6 579	14 635	4 774
Thailand	9 485	3 918	10 143	4 105
West Germany	15 608	6 155	10 145	3 936
Spain	7 456	2 278	10 590	3 317
Mexico	7 570	1 818	11 489	3 038
Turkey	2 956	1 407	6 724	3 022
Belgium-Luxembourg	6 520	2 079	6 843	2 089
Venezuela	4 575	891	7 737	1 924
United Kingdom	9 876	2 992	7 191	1 891
Colombia	2 901	959	4 625	1 534
Malaysia	1 374	617	3 157	1 268
Other countries	46 478	14 668	39 187	13 094
Total	341 609r	102 888r	293 808	90 686
Grand total crude, milled fibres and shorts	717 684	401 086	648 825	363 810

TABLE 1A. (cont'd)

	1986		1987	
	(tonnes)	($000)	(tonnes)	($000)
Manufactured products				
Asbestos cloth, dryer felts, sheets				
United States		660		1 180
United Kingdom		491		348
Thailand		-		174
Other countries		144		724
Total	..	1 295	..	2 426
Brake linings and clutch facings				
United States		2 614		2 482
El Salvador		-		18
Haiti		-		5
Barbados		-		4
Israel		-		3
Other countries		13		6
Total	..	2 627	..	2 518
Asbestos and asbestos cement building materials				
United States		6 592		4 322
Thailand		87		183
Kuwait		175		175
United Arab Emirates		31		92
Pakistan		-		86
Mexico		144		81
Australia		173		79
New Zealand		-		60
Other countries		632		183
Total	..	7 834	..	5 261
Asbestos basic products, n.e.s.				
United States		1 356		2 348
Chile		107		169
West Germany		95		105
Other countries		446		479
Total	..	2 004	..	3 101
Total exports, asbestos manufactured	..	13 760	..	13 306
Imports				
Asbestos, unmanufactured	325	664	238	407
Asbestos, manufactured				
Cloth, dryer felts, sheets, woven or felted		1 193		1 141
Packing	657	2 343	597	2 469
Brake linings		20 676		22 134
Clutch facings		2 057		2 211
Asbestos-cement shingles and siding		18		29
Asbestos-cement board and sheets		298		148
Asbestos building materials, n.e.s.		806		1 060
Asbestos basic products, n.e.s.		1 114		2 816
Total asbestos, manufactured	..	28 505	..	32 008
Total asbestos, unmanufactured and manufactured	..	29 169	..	32 415

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Value of containers not included.

- Nil; n.e.s. Not elsewhere specified; .. Not applicable; r Revised; x Confidential.

TABLE 1B. CANADA, ASBESTOS PRODUCTION AND TRADE, 1988

Item No.		1988P	
		(tonnes)	($000)
Production (shipments)[1]			
By type			
Group 3, spinning		..	..
Group 4, shingle		..	..
Group 5, paper		..	..
Group 6, stucco		..	..
Group 7, refuse		..	..
Total		705 000	268 357
By province			
Quebec		x	x
British Columbia		x	x
Newfoundland		x	x
Total		705 000	268 357
Exports		**(Jan.-Sept.)**	
2524.00	- Asbestos		
2524.00.10	--- Crude		
	India	5 915	2 616
	Japan	1 295	496
	Thailand	572	438
	United States	481	300
	Other countries	1 961	1 101
	Total	10 224	4 951
2524.00.20	--- Milled fibres, group 3 grades		
	United Kingdom	1 251	1 611
	Japan	1 205	1 373
	Mexico	755	1 220
	United States	2 357	973
	Brazil	529	935
	South Korea	568	776
	Other countries	5 019	4 943
	Total	11 684	11 831
2524.00.30	--- Milled fibres, group 4 and 5 grades		
	Japan	29 674	19 143
	India	22 296	18 292
	France	21 947	15 583
	Italy	20 536	15 006
	Thailand	20 429	12 053
	United States	14 029	10 722
	Spain	11 638	8 211
	Other countries	223 335	100 964
	Total	363 884	199 974
2524.00.40	--- Shorts, group 6, 7, 8 and 9 grades		
	Japan	41 483	13 179
	South Korea	26 447	9 542
	United States	43 996	9 036
	India	8 860	3 429
	Taiwan	9 638	2 900
	Spain	7 241	2 727
	Turkey	4 920	2 231
	West Germany	5 096	2 099
	Other countries	84 251	24 788
	Total	231 932	69 931
Grand total crude, milled fibres and shorts		617 724	286 687

TABLE 1B. (cont'd)

Item No.		1988P Jan.-Sept.	
		(tonnes)	($000)
Exports (cont'd)			
68.11	Articles of asbestos-cement, of cellulose fibre-cement or the like		
6811.10	- Corrugated sheets		
	United States		224
	Nicaragua		90
	Total	..	314
6811.20	- Other sheets, panels, tiles and similar articles		
	United States		590
	New Zealand		162
	Other countries		88
	Total	..	840
6811.30	- Tubes, pipes and tube or pipe fittings		
	United States		30
	Total	..	30
6811.90	- Other articles		
	United States		189
	Other countries		31
	Total	..	220
68.12	Fabricated asbestos fibres; mixtures with a basis of asbestos or with a basis of asbestos and magnesium carbonate, articles of such mixtures or of asbestos		
6812.10	- Fabricated asbestos fibres		
	Thailand		486
	United States		457
	Pakistan		383
	Other countries		300
	Total	..	1 626
6812.20	- Yarn and thread		
	United States	99	562
	Other countries	45	205
	Total	144	767
6812.30	- Cords and string, whether or not plaited		
	United States		60
	Total	..	60
6812.40	- Woven or knitted fabric		
	United Kingdom	53	404
	United States	48	349
	Other countries	17	67
	Total	118	820
6812.50	- Clothing, clothing accessories, footwear and headgear		
	Belgium		217
	United States		155
	Other countries		132
	Total	..	504

TABLE 1B. (cont'd)

Item No.		1988P Jan.-Sept.	
		(tonnes)	($000)
Exports (cont'd)			
6812.60	- Paper, millboard and felt		
	United States		3 586
	Mexico		98
	Other countries		463
	Total	..	4 147
6812.70	- Compressed asbestos fibre jointing, in sheets or rolls		
	United States	260	428
	Other countries	...	5
	Total	260	433
6812.90	- Other		
6812.90.10	--- Building materials		
	United States		4 175
	Cameroon		222
	Other countries		306
	Total	..	4 703
6812.90.90	--- Other		
	United States		2 023
	Other countries		486
	Total	..	2 509
68.13	Friction material and articles thereof, not mounted, for brakes, for clutches or the like, with a basis of asbestos, of other mineral substances or of cellulose		
6813.10	- Brake linings and pads		
	United States		12 621
	Other countries		867
	Total	..	13 488
6813.90	- Other		
6813.90.10	--- Clutch facings for motor vehicles		
	United States		6
	Total	..	6
6813.90.90	--- Other		
	United States		390
	Other countries		89
	Total	..	479
Total exports, asbestos manufactured		..	30 946
Imports			
2524.00	Asbestos		
2524.00.10	--- Crude	221	290
2524.00.90	--- Other	111	30
68.11	Articles of asbestos-cement, of cellulose fibre-cement or the like		
6811.10.00	- Corrugated sheets	..	29
6811.20.00	- Other sheets, panels, tiles and similar articles	..	362
6811.30.00	- Tubes, pipes and tube or pipe fittings	..	54
6811.90.00	- Other articles	..	679

TABLE 1B. (cont'd)

Item No.		1988P Jan.-Sept.	
		(tonnes)	($000)
Imports (cont'd)			
68.12	Fabricated asbestos fibres; mixtures with a basis of asbestos or with a basis of asbestos and magnesium carbonate; articles of such mixtures or of asbestos		
6812.10.00	- Fabricated asbestos fibres; mixtures with a basis of asbestos or with a basis of asbestos and magnesium carbonate	..	379
6812.20.00	- Yarn and thread	14	112
6812.30.00	- Cords and string, whether or not plaited	..	57
6812.40.00	- Woven or knitted fabric	40	451
6812.50.00	- Clothing, clothing accessories, footwear and headgear	..	158
6812.60.00	- Paper, millboard and felt	..	494
6812.70.00	- Compressed asbestos fibre jointing, in sheets or rolls	244	1 416
6812.90	- Other		
6812.90.10	--- Belting	..	1
6812.90.90	--- Other	..	4 005
68.13	Friction material and articles thereof, not mounted, for brakes, for clutches or the like, with a basis of asbestos, of other mineral substances or of cellulose		
6813.10	- Brake linings and pads	..	18 335
6813.90	- Other	..	2 967

Sources: Statistics Canada; Energy, Mines and Resources Canada.
.. Not applicable; P Preliminary; x Confidential; ... Amount too small to be expressed.
Note: Numbers may not add to totals due to rounding.

TABLE 2. CANADIAN ASBESTOS PRODUCERS, 1988

Producers	Mine Location	Normal Mill Capacity ore/day	Normal Mill Capacity fibre/year	Remarks
		(tonnes)		
Baie Verte Mines Inc.	Baie Verte, Nfld.	6 600	80 000	Open-pit.
LAB Chrysotile Inc.[1]				Partnership owned 55% LAQ and 45% Société nationale de l'amiante (SNA)
- Lac d'amiante du Québec, (LAQ)	Black Lake, Que.	9 000	160 000	Open-pit. A joint venture with ASARCO Incorporated and Campbell Resources Inc.
- Asbestos Corporation Limited				(SNA) Quebec Crown corporation.
British Canadian mine	Black Lake, Que.	7 000	70 000	Open-pit.
- Bell Asbestos Mines, Ltd.	Thetford Mines, Que.	2 700	70 000	(SNA) Quebec Crown corporation. Underground. Closed in May; will reopen January 1989.
J M Asbestos Inc. Jeffrey mine	Asbestos, Que.	15 000	300 000	Open-pit (effective capacity reduced by one-half in 1982).
Cassiar Mining Corporation	Cassiar, B.C.	5 000	100 000	Open-pit; some wet-milling production; development work for underground McDame orebody started.
Total of four producers at year-end			780 000	

---

[1] A partnership involving three operating companies.

TABLE 3. CANADA, ASBESTOS PRODUCTION AND EXPORTS, 1982-88

	Crude	Milled	Shorts	Total
		(tonnes)		
Production[1]				
1982	-	394 554	439 695	834 249
1983	-	448 953	408 551	857 504
1984	-	442 503	394 151	836 654
1985	-	397 729	352 461	750 190
1986		332 092	330 289	662 381
1987				664 546
1988P	..	..	..	705 000
Exports				
1982	555	454 430	425 699	880 684
1983	931	384 068	368 912	753 911
1984	1 729[r]	430 495[r]	363 629[r]	795 853
1985	44[r]	395 158[r]	326 311[r]	721 513
1986	127	375 948[r]	341 609[r]	717 684[r]
1987	1 696	353 321	293 808	648 825
1988[2]	10 224	375 568	231 932	617 724

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Producers' shipments. [2] Jan.-Sept.
P Preliminary; - Nil; .. Not available; [r] Revised.

TABLE 4. ASBESTOS: WORLD PRODUCTION BY COUNTRY, 1987

Country	Tonnes[e]
U.S.S.R.	2 500 000
Canada	650 580
Brazil	210 000
Zimbabwe	164 000
China	150 000
Republic of South Africa[1]	135 074
Italy	120 000
United States[2]	50 600
Greece	48 000
India	28 000
Indonesia	25 000
Swaziland	21 000
Cyprus	13 000
Colombia	13 000
Yugoslavia[1]	10 964
Japan	4 000
Korea	3 000
Turkey	1 500
Argentina	1 000
Bulgaria	500
Egypt	400
Total	4 149 668

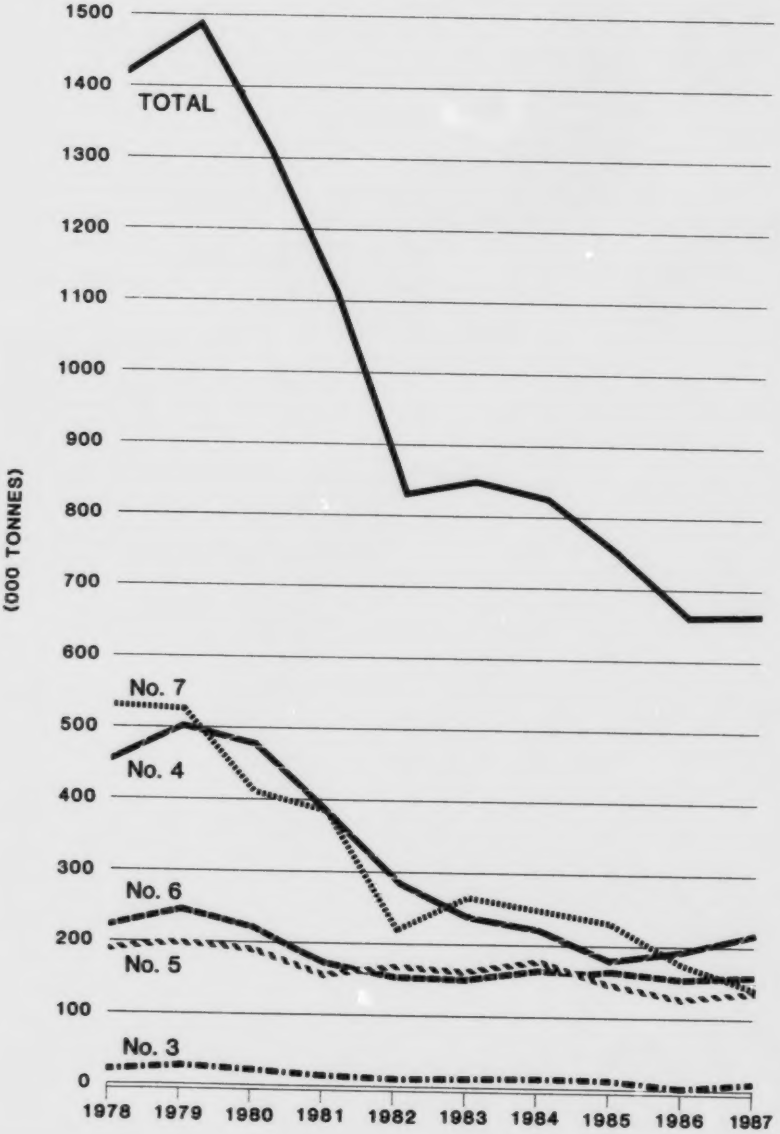
Sources: U.S. Bureau of Mines; Energy, Mines and Resources Canada.
[1] Reported figure. [2] Sold/used by producers.
[e] Estimated.

TABLE 5. CANADIAN ASBESTOS CONSUMPTION, 1985-87

	1985		1986		1987P	
	(tonnes)	(%)	(tonnes)	(%)	(tonnes)	(%)
Paper; textiles, a/c sheet; a/c pipe; insulation; roofing	7 062	35	7 165	52	5 662	52
Flooring products, plastics; coatings and compounds	6 607	33	3 243[r]	24	1 003	9
Friction products; packing and gaskets	6 309	32	3 273	24	4 278	39
Total	19 978	100	13 681[r]	100	10 943	100

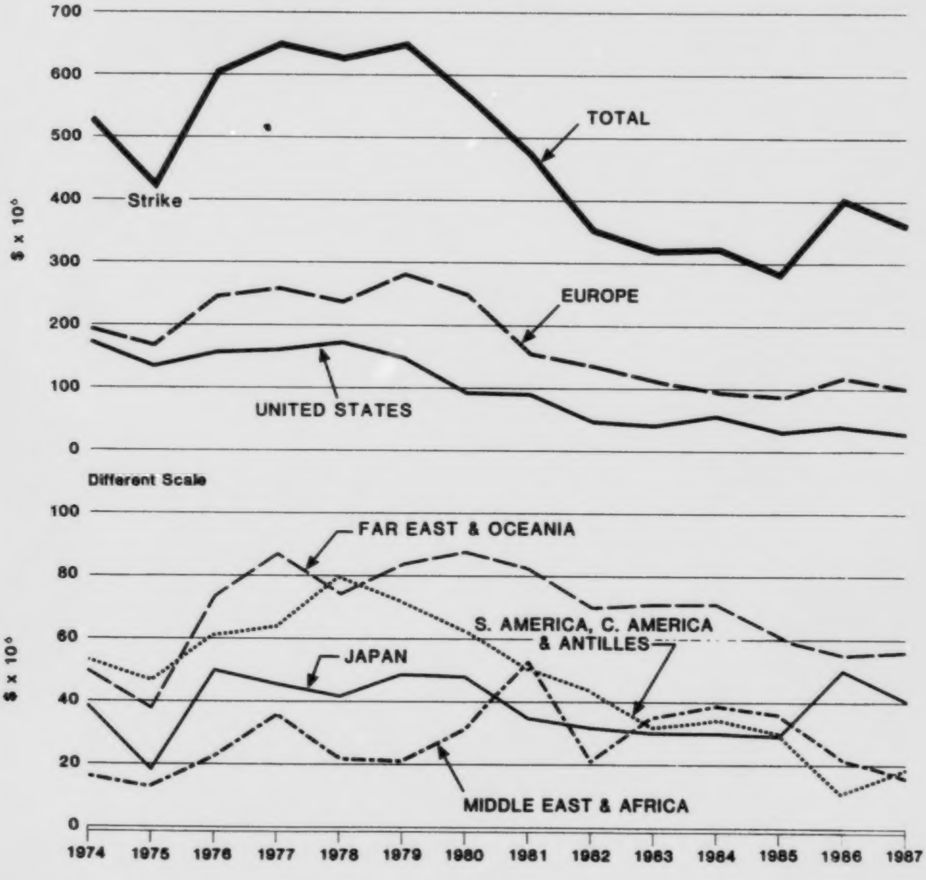
P Preliminary; [r] Revised.

CANADIAN ASBESTOS SHIPMENTS 1978-87



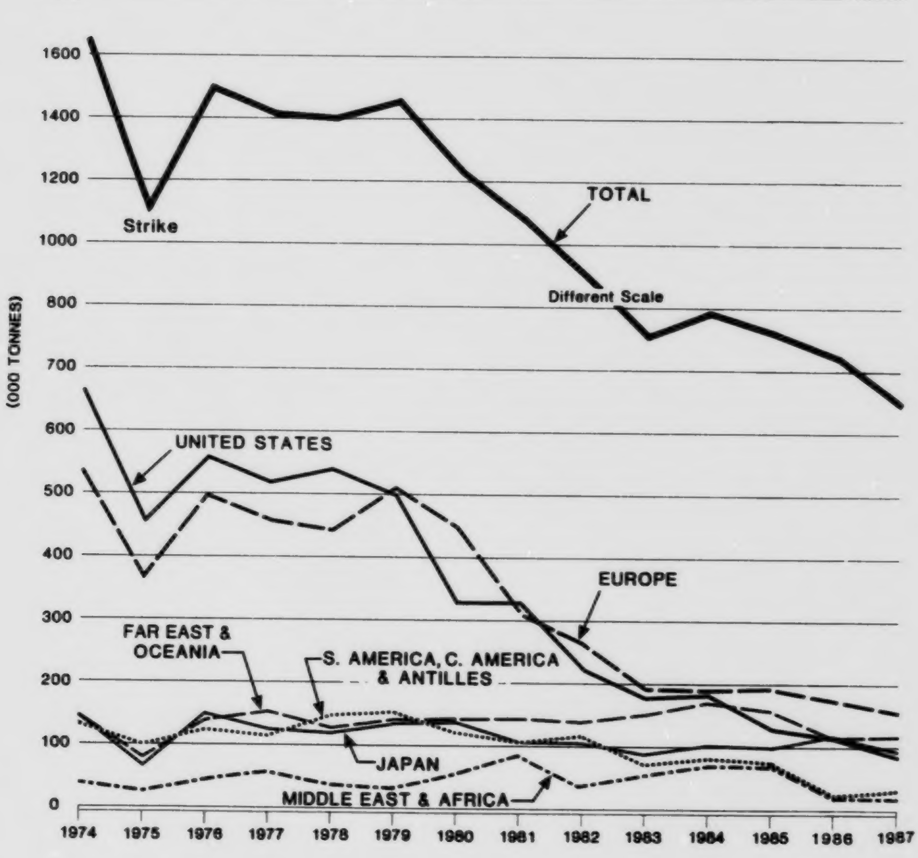
CANADIAN EXPORTS OF ASBESTOS (ALL GROUPS) BY COUNTRY OR REGION (1974-87)

(Constant 1979 $)



CANADIAN EXPORTS OF ASBESTOS (ALL GROUPS) BY COUNTRY OR REGION (1974-87)

(000 Tonnes)



Cadmium

H.L MARTIN

Cadmium metal is recovered principally as a by-product of zinc smelting and refining. Present in virtually all zinc ores, cadmium production in Canada varies between 2-3 kg of cadmium metal for each tonne of zinc metal produced. As the world's largest producer of zinc, Canada's continuing position as a dominant world source for cadmium seems assured.

CANADIAN PRODUCTION

Only about half of Canada's annual mine production of zinc concentrates is processed in Canada at four zinc refineries, which are also the source of Canada's cadmium metal production. In 1988, Canada's refinery production of cadmium metal from all sources (domestic, imported and secondary), reached a record level estimated at 1 693 700 kg, some 8% greater than the 1987 figure of 1 571 444 kg. At this production level, Canada is the world's fourth largest producer of cadmium metal, behind the U.S.S.R., Japan and the United States.

Canada's production of cadmium metal from domestic sources plus the paid-for cadmium content of exported concentrates reached an estimated 1 741 700 kg in 1988, up 18% over 1987s 1 481 416 kg. However, the value of production reached an extraordinary $32.8 million, almost four times the $8.6 million recorded in 1987, due to a steep rise in cadmium prices that averaged C$18.84/kg during 1988, well above the 1987 average of C$5.81/kg.

WORLD PRODUCTION

Production of cadmium metal in the western world, as reported by the World Bureau of Metal Statistics, peaked at 15 417 t in 1984, dropping to 14 730 t in 1987, well below the record consumption of 16 086 t established that year. Production/consumption of cadmium in the socialist countries is estimated to be in the order of 4 000 t/y. Despite an apparent western world primary production capacity for cadmium of about 17 000 t/y, zinc refineries cannot boost their cadmium output to take full advantage of the high cadmium prices. Cadmium production, a by-product of zinc refining, is not only dependent on the level of zinc production but also on the recoverable cadmium content of the zinc concentrates and on the nature of the refinery process.

Cadmium production in the western world is likely to remain at the 15 000 t/y level for the near term, though availability of the metal could be improved if recycling of spent nickel-cadmium (Ni-Cd) batteries were increased. Not until the Cominco Ltd. Red Dog zinc-lead mine in Alaska comes on-stream in 1990-91 will cadmium supplies expand significantly, as the deposit contains high grades of both zinc and cadmium.

USES

The rising demand for cadmium is a direct result of the rapidly growing use of Ni-Cd rechargeable batteries, a market worth more than US$1 billion annually. For 1988, various estimates of cadmium usage by battery manufacturers range from 6 100 to 7 500 t, or up to about half of the total western world consumption. About 70% of this consumption is in portable battery systems (e.g. cellular telephones) where average annual growth has been between 10-15% for the last five years. In contrast, industrial Ni-Cd batteries have experienced much lower growth rates. Japan in particular has accelerated its Ni-Cd battery production, this application now accounts for about 80% of its annual consumption of about 3 000 t in 1988, up from 2 272 t in 1987. Japan, the western world's largest cadmium metal producer, became a net importer of the metal in 1987 owing to its increased production of Ni-Cd batteries. Japan is also believed to be stockpiling cadmium in anticipation of supply shortages in 1989.

With a nickel-cadmium ratio of 3:1 in Ni-Cd batteries, the price of cadmium is but a minor fraction in the final price of these batteries, or in the products they are

---

H.L. Martin is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 992-3731.

designed to power. Thus, for the near-term, high cadmium prices should not significantly affect battery demand. However, research into new battery technologies and nickel and cadmium substitutes is being accelerated.

Other major end-uses for cadmium are in pigments and electroplating, with lesser amounts used as stabilizers in the plastics industry and in alloys. Cadmium consumption for these applications is declining, owing in large part to environmental and health concerns. Cadmium is toxic; acute exposure to cadmium fumes, dusts and effluents can cause irreversible kidney damage. Most governments, including provincial governments in Canada, have enacted regulations to limit cadmium exposure, especially for workers. In 1979, Sweden banned all production and imports of cadmium-containing products, although exemptions for certain applications were subsequently introduced. The ban has had repercussions on the use of cadmium. The Commission of the European Economic Communities has been requested to intensify and expand its studies into the effects of cadmium contamination, and recommendations have been made to the effect that cadmium should be limited to uses where no suitable alternatives exist. More R&D for cadmium substitutes has been urged, and it has been recommended that products containing cadmium, notably batteries, be collected and recycled.

PRICES

The tripling in price for cadmium during 1988 followed an already surprising record year in 1987. After five years of average monthly New York dealer prices, ranging from a low of US$0.68/lb. in December 1982 to a high of US$1.60/lb. in May 1984 (Metals Week), cadmium prices spiralled from US$0.95/lb. to US$3.20/lb. during 1987. The price momentum continued into 1988, reaching a record US$9.25/lb. in early March, easing back to the US$5-8 range for the remainder of the year. At year end the price closed above US$8/lb. Cadmium prices are expected to remain high during 1989 owing to a continued shortfall in supplies while demand is growing, particularly for the manufacture of nickel-cadmium batteries.

OUTLOOK

Despite the environmental and health concerns, the strong demand for nickel-cadmium batteries both in Japan and the United States points to a continued buoyant market for cadmium in 1989. Moreover, the recent acquisition of nickel-cadmium battery technology by the U.S.S.R. and the People's Republic of China offers considerable scope for further sharp increases in world cadmium consumption.

TARIFFS

Item No.	Description	Canada			United States	EEC	Japan[1]
		MFN	GPT	USA	Canada	MFN	MFN
26.17	Other ores and concentrates						
26.17.90.00	- Other						
2617.90.00.30	----- Cadmium	Free	Free	Free	Free	Free	Free
2825.90.90	Other inorganic bases; other metal oxides, hydroxides and peroxides						
2825.90.90.10	--- Cadmium oxide	Free	Free	Free	2.9%	11%	5.8%
2830.30.00	Cadmium sulphide	Free	Free	Free	2.4%	6.9%	3.7%
81.07	Cadmium and articles thereof, including waste and scrap						
8107.10	- Unwrought cadmium; waste and scrap; powders						
8107.10.10	--- Unwrought cadmium, not alloyed; powders, not alloyed	Free	Free	Free	Free	4%	5.1%
8107.10.20	--- Unwrought cadmium, alloyed; waste and scrap; powders, alloyed	10.2%	6.5%	8.1%	Free	4%	5.1%
8107.90.00	- Other	10.2%	6.5%	8.1%	4.4%	6%	6.5%

Sources: Customs Tariffs, effective January 1989, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States (First Edition Supplement 2) effective January 1, 1989; Official Journal of the European Communities, Vol. 30, No. L256, 1987, "Conventional" column; Custom Tariff Schedules of Japan, 1988.

[1] GATT rate is shown, lower tariff rates may apply circumstantially.

TABLE 1A. CANADA, CADMIUM PRODUCTION AND EXPORTS, 1986 AND 1987, AND CONSUMPTION, 1985-87

	1986		1987	
	(kilograms)	($000)	(kilograms)	($000)
Production				
All forms[1]				
Ontario	807 457	3 087	921 483	5 355
Quebec	43 743	167	108 490	630
British Columbia	304 468	1 164	200 792	1 167
Manitoba	118 437	453	94 838	551
Northwest Territories	175 211	670	86 133	551
New Brunswick	27 222	104	65 623	381
Yukon	2 088	8	2 180	13
Saskatchewan	5 281	20	1 957	11
Total	1 483 907	5 673	1 481 496	8 609
Refined[2]	1 565 375	..	1 580 516	..
Exports				
United States	1 042 817	3 731	874 676	4 304
United Kingdom	234 587	651	174 914	441
Netherlands	104 870	242	79 575	171
Other countries	533	63	27 390	160
Total	1 382 807	4 687	1 156 555	5 076

	1985	1986	1987
		(kilograms)	
Consumption			
Cadmium metal[3]			
Plating	15 854	13 219	12 490
Solders, other alloys and other uses[4]	13 828	4 153	6 429
Total	29 682	17 372	18 919

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Production of refined cadmium from domestic ores, plus recoverable cadmium content of exported ores and concentrates. [2] Refined metal from all sources and cadmium sponge. [3] Available data reported by consumers. [4] Chemicals and pigments.

.. Not available.

TABLE 1B. CANADA, CADMIUM PRODUCTION AND EXPORTS, 1988P

Item No.		1988P	
		(kilograms)	($000)
Production			
All forms[1]			
Ontario		796 650	15 009
British Columbia		318 541	6 001
Northwest Territories		218 900	4 124
Quebec		209 862	3 954
Manitoba		86 299	1 626
New Brunswick		84 375	1 590
Yukon		24 300	458
Saskatchewan		2 730	51
Total		1 741 657	32 813
Refined[2]		1 835 500	..
Imports		(Jan.-Sept.)	
2825.90.90.10	Cadmium oxide		
	Belgium	34 688	261
	West Germany	12 000	255
	Other countries	45 698	278
	Total	92 386	794
2830.30.00	Cadmium sulphide		
	United States	18 207	12
	Total	18 207	12
81.07	Cadmium and articles thereof, including waste and scrap		
8107.10	- Unwrought cadmium; waste and scrap; powders		
8107.10.10	--- Unwrought cadmium, not alloyed; powders, not alloyed		
	United States	1 811	35
	Total	1 811	35
8107.10.20	--- Unwrought cadmium, alloyed; waste and scrap; powders, alloyed		
8107.10.20.10	----- Unwrought cadmium, powders		
	United States	94	3
	Total	94	3
8107.10.20.20	----- Waste and scrap		
	Zaire	673	10
	United States	578	...
	Total	1 251	10
8107.90.00	- Other		
	United States	10 145	155
	Total	10 145	155
Exports			
2830.30.00	Cadmium sulphide		
	United States	2 278	48
	Total	2 278	48

TABLE 1B. (cont'd)

Item No.		1988P Jan.-Sept. (kilograms)	1988P Jan.-Sept. ($000)
Exports (cont'd)			
81.07	Cadmium and articles thereof, including waste and scrap		
8107.10	- Unwrought cadmium; waste and scrap; powders		
	Japan	256 010	4 299
	United States	366 414	3 980
	United Kingdom	178 337	1 990
	Other countries	12 420	23
	Total	813 181	10 292
8107.90	- Other		
	United States	143 534	1 971
	United Kingdom	38	13
	Other countries	443	23
	Total	144 015	2 007

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Production of refined cadmium from domestic ores, plus recoverable cadmium content of exported ores and concentrates. [2] Refined metal from all sources and cadmium sponge.
P Preliminary; .. Not available; ... Amount too small to be expressed.

TABLE 2. CANADA, CADMIUM PRODUCTION AND EXPORTS, 1975 AND 1980-88

	Production		Exports
	All Forms[1]	Refined[2]	Cadmium Metal
	(kilograms)		
1975	1 191 674	1 142 508	637 797
1980	1 033 000	1 302 955	1 095 825
1981	833 788	1 293 265	1 452 904
1982	886 055	1 162 390	769 505r
1983	1 107 000	1 296 000	1 365 111
1984	1 605 300	1 756 707	1 369 422
1985	1 716 731	1 696 192	1 477 415
1986	1 483 907	1 565 375	1 382 807
1987	1 481 496	1 580 516	1 156 555
1988P	1 741 657	1 835 500	(3)

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Production of refined cadmium from domestic ores plus recoverable cadmium content of exported ores and concentrates. [2] Refined metal and cadmium sponge from all sources.
(3) See Table 1B.
P Preliminary; r Revised.

TABLE 3. CANADA, CADMIUM METAL CAPACITY, 1987

Company and Location	Annual Capacity
	(tonnes)
Cominco Ltd. Trail, British Columbia	570
Canadian Electrolytic Zinc Limited Valleyfield, Quebec	465
Falconbridge Limited Timmins, Ontario	640
Hudson Bay Mining and Smelting Co., Limited Flin Flon, Manitoba	200
Total Canada	1 875

TABLE 4. WESTERN WORLD CADMIUM METAL PRODUCTION, 1983-88

Continent and Country	1983	1984	1985	1986	1987	Jan.-June 1988P
			(tonnes)			
Europe						
Austria	46	50	52	53	25	9
Belgium	1 217	1 450	1 293	1 374	1 291	907
Finland	616	614	564	523	687	435
France	447	447	365	444	293	134
Germany, F.R.	1 094	1 111	1 095	1 218	1 125	681
Italy	386	520	360	300	320	150
Netherlands	513	636	598	565	517	251
Norway	117	152	164	154	147	82
Spain	278	290	268	247	297	155
United Kingdom	340	390	370	379	498	164
Yugoslavia	48	270	279	259	284	142
Africa						
Algeria	32	80	128	124	102	51
Namibia	51	41	60	75	50	..
Zaire	308	318	295	364	299	150
Asia						
India	131	143	190	160	213	116
Japan	2 215	2 400	2 555	2 542	2 374	1 244
Republic of Korea	460	410	450	455	460	230
Turkey	10	31	32	6	11	6
Americas						
Canada	1 296	1 774	1 712	1 554	1 579	1 116
Mexico	847	894	852	764	829	448
Peru	443	..	..	..	..	..
United States	1 382	2 066	1 678	2 352	2 176	1 269
Other Americas	210	271	270	270	260	165
Australia	1 104	1 060	879	870	894	386
Western World	13 591	15 418	14 509	15 052	14 731	8 291

Sources: World Bureau of Metal Statistics.
P Preliminary; .. Not available.

Cement

O. VAGT

SUMMARY

In 1988, construction activity in Canada changed from a residential emphasis - although still relatively strong - to more commercial, institutional and engineering construction. Total cement shipments were 12.6 Mt, about the same as last year based on preliminary figures. Exports of cement to the United States increased marginally. Slag cement is considered elsewhere and is classified under Miscellaneous Nonmetallic Minerals.

Canadian cement production capacity was reduced to 14.77 Mt/y (Table 2) mainly resulting from a plant closure in 1987. Given the strong demand in 1988, imports of both clinker and cement increased.

Following the economic recovery in Canada since the 1982-84 recessionary period, construction expenditures related particularly to residential building expanded rapidly. The commercial and institutional building sectors expanded to a lesser extent, however expenditures related to engineering construction, with gas and oil facilities accounting for up to one-third, continued relatively low until the broader upturn in 1988.

THE CANADIAN INDUSTRY

The Canadian cement industry is diversified and vertically integrated into the closely related construction materials and products fields. Many cement manufacturers also supply ready-mix concrete, stone, aggregates and concrete products such as slabs, bricks and pre-stressed concrete units. The industry is now 81% foreign-controlled; it is strongly regionalized with capacity concentrated near growth areas, some of which are convenient to United States market access. Some plants in fact, were located for ready access to existing United States markets by utilizing waterborne, high-bulk transportation facilities. In 1986, S.A. Cimenteries CBR of Belgium purchased the cement assets of Genstar Cement Limited. These operations, now under CBR Cement Canada Limited, represent 15% of domestic capacity. Also, Société des Ciments Français, the second largest cement company in France, acquired Lake Ontario Cement Limited which accounts for 10% of capacity. The CBR plants in the "inland" western provinces will continue under the name, Inland Cement Limited. In British Columbia, CBR's cement operations conduct business under the name of Tilbury Cement Limited with production facilities in Delta and distribution centres throughout the province.

St. Lawrence Cement Inc.'s acquisitions of cement plants in New York and Maryland in 1984-85, along with cement distribution terminals, increased capacity substantially which in the United States remains at about 1.1 Mt. The company announced in August 1988, that it will invest US$190 million to build a 900 000 t/y cement plant in Hudson, New York. The plant is strategically located to supply the important northeastern U.S. market beginning in 1993. In Canada, recent capital expenditures have mainly gone towards upgrading production facilities and the concrete ready-mix fleet.

St. Marys Cement Corporation has a manufacturing facility, St. Marys Peerless Cement Company, in Detroit, Michigan, with distribution terminals in Michigan, Wisconsin, Illinois and Indiana. St. Marys also operates a terminal, St. Marys New York Cement Inc., in Buffalo, New York.

Lake Ontario Cement Limited is well integrated into the concrete products field and continued this policy through the Building Products Group. The acquisition in 1986 of Universal Concrete Products Inc., of Columbus, Ohio, provides a major extension of the companys current market area as far south as the Carolinas. Also, acquisitions of ready-mix operations in North Bay, Ottawa and Maitland were initiated and completed in the period 1985 to 1987.

O. Vagt is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 992-2667.

Shipments by Lafarge Canada Inc. - name changed from Canada Cement Lafarge Ltd. in January 1988 - continued strong in 1988 including those destined to the Great Lakes distribution network acquired by Lafarge Corporation late in 1986.

Two plants in the **Atlantic region**, which obtain raw materials on site or nearby, constitute just over 4% of total Canadian clinker producing capacity. North Star Cement Limited completed extensive renovation in 1987 for improving fuel efficiency at its Corner Brook, Newfoundland plant. Lafarge Canada Inc. plant at Brookfield, Nova Scotia provided clinker based on requirements of the company's plant at Havelock, New Brunswick. Consumption in the Atlantic region was nearly 500 000 t in 1987, an increase of nearly 20% from the 1986 level.

In the Quebec region, four clinker producing plants account for 24% of Canadian output in a region which in 1987 consumed about 2.3 Mt of portland cement or 26% of total Canadian consumption.

St. Lawrence Cement installed a new grinding mill expected to increase grinding capacity to 675 000 t/y at its plant in Beauport.

Miron Inc. announced plans to proceed with a $120 million project at Grondines to develop a new limestone quarry and cement plant to produce 600 000 t/y of cement including clinker. The project will replace the company's long-time source of raw material, the Montreal quarry, sold to the City. Purchases of cement as well as clinker will continue from outside sources until the project is completed after 1990.

Portland cement consumption increased in the **Ontario region** where 44% of the nation's clinker-producing capacity is concentrated. Lafarge Canada Inc. has brought into production about 3 Mt of new cement capacity over the past ten years and most of its operating kilns are relatively new. Limestone for Lafarge's Bath, Ontario plant is quarried on site and silica is supplied from Potsdam sandstone at Pittsburgh, about 65 km east of Bath. Iron oxide and gypsum are purchased from Hamilton and Nova Scotia, respectively. The Woodstock plant has experimented with the use of refuse-derived fuel (RDF). The plant obtains limestone on site, silica from Falconbridge Limited, iron oxide from Stelco Inc. and gypsum from southern Ontario.

At Picton, Lake Ontario Cement Limited operates one of the largest cement plants in North America. The four-kiln plant supplies cement and clinker to its associated companies in the United States - Rochester Portland Cement Corp. in New York state and Aetna Cement Corporation in Michigan - and cement to its Ontario markets.

St. Lawrence Cement Inc. began work at its Mississauga plant on a $13.5 million kiln modification expected to result in reduced production costs in 1989. Limestone is from Ogden Point, 125 km east of Toronto on the shore of Lake Ontario. The company continued work on its Resource Recovery/Refuse Derived Fuel (RDF) project. Following an acceptable assessment by environmental authorities, plans are to replace up to 20% of the company's coal consumption with RDF produced from local non-hazardous Municipal Solid Waste. Expanding aggregate operations and reserves of raw material remain major objectives. Gypsum is purchased from Nova Scotia or from southern Ontario mines.

St. Marys Cement announced plans for a $160 million plant expansion to at least double production capacity at Bowmanville by mid-1991. A state-of-the-art, dry-process system will replace two wet process kilns and production of limestone on site will be increased accordingly.

Two companies, Lafarge Canada Inc. and CBR's Inland/Tilbury operations, operate a total of five clinker producing plants in the **Prairie region** and three in the **Pacific region** along with one clinker grinding plant. This **western region** has 30% of clinker producing capacity, including the recently completed expansion at Inland's Edmonton, Alberta plant. Consumption of portland cement in the western provinces accounted for 31% of total Canadian use. Recent expansions at Edmonton and at Exshaw increased capacity by about 1.3 Mt/y.

A limestone quarry at Mafeking, Manitoba, near the Manitoba-Saskatchewan border, supplies limestone to Inland's Regina plant, while the Winnipeg plant is supplied from Steep Rock, Manitoba.

Raw materials for Lafarge's Exshaw plant are mainly from on site sources but gypsum and iron oxide respectively, are provided by Westroc Industries Limited and Cominco Ltd. Lafarge's Vancouver plant at

Richmond, as well as Tilbury's plant, utilizes limestone from Texada Island. The company's Kamloops plant is supplied from reserves close to the plant site.

NORTH AMERICAN TRADE

The trend continues toward an interconnected North American cement market, however imbalances continue as a result of reduced industry capacity in the United States and record imports.

Exports of Canadian cement and clinker are mainly to bordering states, particularly New York, Vermont, Michigan, Minnesota and Washington. Canadian cement production efficiencies and a relatively strong American dollar continue to make Canadian cement and clinker competitive in their own right. Concerns relating to low-cost imports from Mexico, Spain and Venezuela into the United States have now altered somewhat in favour of strategies taking advantage of low prices.

There were no major acquisitions or closures affecting Canadian operations in 1988.

The U.S. Department of Commerce published in 1987 some findings in response to unprecedented rapid changes mainly related to foreign ownership and record imports of cement. Major topics reviewed included reasons for shifts in the balance of trade and the influences of low international freight rates and exchange rates.

TECHNOLOGY

Research relating to cement manufacture is concentrated in the pyroprocessing sector accounting for over 80% of the energy requirements. Raw material grinding and finish grinding are being studied to determine optimum particle size for energy consumed. Energy conservation programs adopted by the Canadian cement industry have reduced the energy consumption per unit of production by 22% between 1974 and 1987. In 1987 the Canadian cement industry on average consumed 4 845 megajoules a tonne of production of which 4 292 megajoules was derived from fossil fuels.

The fuel mix has changed considerably during recent years away from natural gas and petroleum products toward coal/coke. In 1987, percentages were 31.6, 4.5 and 63.9 respectively. Dry process plants accounted for 82.5% of total Canadian cement production in 1987.

On-going research sponsored through CANMET and relating to supplementary cementing materials led to the successful use of blast furnace slag for manufacturing a slag cement. Reiss Lime Company of Canada, Limited is now producing this type of cement from a grinding plant at Spragge, Ontario, using granulated slag from The Algoma Steel Corporation, Limited's, Sault Ste. Marie plant. Plant capacity is 200 000 t/y of slag cement for complete or partial replacement of Portland cement, depending on requirements. The primary use at present is in mine backfill, however, construction-related uses are also being investigated.

Research in the private sector is conducted on behalf of all cement producers by the Portland Cement Association (PCA), a non-profit research group sponsored by the cement industry. Individual producers generally have research facilities varying in size from a customer service unit to a large laboratory; in the case of Lafarge's new Montreal-based facility, mandated "to develop new manufacturing processes and improve cement and concrete products tailored to the Canadian and United States markets."

WORLD DEVELOPMENTS

World cement production in 1987 was 1 033 Mt, according to the U.S. Bureau of Mines. China ranked number one, leading all countries with 180 Mt, followed by the U.S.S.R. at 136 Mt and the United States at 72 Mt.

Most countries are capable of supplying their own raw material requirements for cement manufacture when a plant is warranted. Normally, market range is strictly limited by transportation costs, however large additional sales may warrant a secondary distribution terminal. Few countries rely entirely on imports for their cement needs, however in recent years multinational companies with widespread production and distribution networks have become much more important in world markets. An outstanding recent example of this is the partial consolidation of the United States, Canada and Mexico cement industries by European ownership to effect very broad regional marketing. At the beginning of 1988 more than 60% of the U.S. industry was owned by foreign companies.

USES

Portland cement is produced by burning, usually in a rotary kiln, an accurately proportioned, finely ground mixture of limestone, silica, alumina and iron oxide. The three most commonly-used types of cement are Normal Portland, High-Early-Strength Portland and Sulphate-Resisting Portland are produced by most Canadian cement manufacturers.

Cement has little use alone, but when combined with water, sand, gravel, crushed stone or other aggregates in proper proportions, acts as a binder for concrete. Concrete has become a readily adaptable material capable of being poured on site for large engineering projects, or used in the form of delicate precast panels or as heavy, prestressed columns and beams in building construction.

Moderate Portland Cement and Low-Heat-of-Hydration Portland Cement, designed for concrete poured in large masses, such as in dam construction, are manufactured by several companies in Canada. Masonry cement (generic name) includes such proprietary product names as Mortar Cement, Mortar Mix (unsanded), Mason's Cement, Brick Cement and Masonry Cement. The latter product produced by Portland cement manufacturers is a mixture of Portland cement, finely ground high-calcium limestone (35 to 65% by weight) and a plasticizer. The aforementioned products do not necessarily consist of Portland cement and limestone, but may include mixtures of Portland cement and hydrated lime and/or other plasticizers.

Portland cement used in Canada should conform to the specifications of CAN 3-A5-M83, published by the Canadian Standards Association (CSA). This standard covers the five main types of Portland cement. Masonry cement produced in Canada should conform to the CAN 3-A8-M83. Blended hydraulic cements are covered by CAN 3-A362-M83. The cement types manufactured in Canada, but not covered by the CSA standards, generally meet the appropriate specifications of the American Society for Testing and Materials (ASTM).

OUTLOOK

Canada's economic recovery slowed to an annual inflation-adjusted growth rate of 2.8% in the third quarter of 1988, down from 4% in the second quarter. Upward pressure on interest rates in the summer eased in October; however fears of inflation remain following 5 years of growth. Canadian business investment (machinery and equipment and non-residential construction) began to increase considerably starting in the last quarter of 1987. Housing starts rose to 245 986 in 1987 and are expected to be about 220 000 in 1988, exceeding most early predictions. Indicators including relatively stable interest rates, falling unemployment and moderate consumer prices suggest a positive outlook for the building construction sector. Nevertheless, housing starts in 1989 are expected to decline to a more sustainable level of 180-200 000 annually. The robust 5% expansion in Ontario is expected to slow in 1989 and weaker residential construction in Quebec may result in some slowdown, according to projections in late 1988 by the Conference Board of Canada.

The Canadian Construction Association is predicting increases in the non-residential contract construction industry constant dollar expenditures of about 4% through the 1989-91 period. The construction industry as a whole has expressed concern that Canada's large infrastructure network deserves attention now rather than delaying until major renovation and upkeep projects are needed. Such a program would permit the construction industry, and the dependent portion of the mining industry, to plan five to ten years ahead with overall benefits in efficiency.

Conservation of energy and raw materials is a worldwide concern and a factor influencing major developments in the industry. Of particular note is the emphasis on blended cements and the utilization of slag, ash and other by-products.

TARIFFS

Item No.	Description	Canada MFN	Canada GPT	Canada USA	United States Canada
2523.10	- Cement clinker	Free	Free	Free	Free
	- Portland cement				
2523.21	-- White cement whether or not artificially coloured	81.59¢/t	54.25¢/t	Free	Free
2523.29	-- Other	Free	Free	Free	Free
2523.30	- Aluminous cement	Free	Free	Free	Free
2523.90	- Other hydraulic cements	Free	Free	Free	Free
68.10	Articles of cement, of concrete or of artificial stone, whether or not reinforced				
6810.11	-- Building blocks and bricks	5%	Free	4%	3.9%
6810.19	-- Other	8%	Free	6.4%	3.9%
6810.20	- Pipes	9.8%	6.5%	7.8%	3.9%
6810.91	-- Prefabricated structural components for building or civil engineering	6.8-8%	4.5%-Free	5.4-6.4%	3.9%
6811.90	- Articles of asbestos cement, fibre cement or the like, n.e.s.	8%	5%	6.4%	Free

Sources: Customs Tariffs, effective January 1989, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States (First Edition Supplement 2) effective January 1, 1989.
n.e.s. Not elsewhere specified.

TABLE 1A. CANADA, CEMENT PRODUCTION AND TRADE, 1986 AND 1987

	1986		1987	
	(tonnes)	($000)	(tonnes)	($000)
Production[1]				
By province				
Ontario	4 437 345	343 086	5 512 464	437 808
Quebec	3 249 209	190 289	3 615 826	229 987
Alberta	949 354	113 371	1 106 780	116 947
British Columbia	1 071 108	73 696	1 307 849	88 358
Manitoba	415 192	43 733	x	46 755
Nova Scotia	x	25 430	x	46 464
Saskatchewan	x	16 683	x	17 735
Newfoundland	x	8 530	x	9 722
New Brunswick	x	9 526	x	3 451
Total	10 611 223	824 344	12 603 164	997 227
By type				
Portland	9 929 135	778 321	11 511 908	925 942
Masonry[2]	682 088	46 023	1 091 256	71 285
Total	10 611 223	824 344	12 603 164	997 227
Exports				
Portland cement				
United States	2 631 425	135 720	2 800 444	134 777
Cuba	-	-	1 072	152
St. Pierre-Miquelon	932	78	1 005	95
Cameroon	984	69	-	-
Other countries	1 903	112	445	33
Total	2 635 244	135 979	2 802 966	135 057
Prestressed concrete structures				
United States	..	38 750	..	37 489
Others	..	75	..	389
Total	..	38 825	..	37 878
Cement and concrete basic products				
United States	..	59 786	..	58 326
Other countries	..	336	..	1 202
Total	..	60 122	..	59 528
Imports				
Portland cement standard				
United States	202 020	15 476	280 377	19 164
Spain	30 862	1 072	85 591	2 994
Other countries	-	-	30 372	1 075
Total	232 882	16 548	396 340	23 233
White cement				
United States	1 916	232	4 902	413
Belgium-Luxembourg	1 399	131	2 190	274
Japan	686	129	104	14
Total	4 001	492	7 196	701
Aluminous cement				
United States	6 539	1 964	14 963	2 522
Other countries	-	-	29	4
Total	6 539	1 964	14 992	2 526

TABLE 1A. (cont'd)

	1986		1987	
	(tonnes)	($000)	(tonnes)	($000)
Imports (cont'd)				
Cement, n.e.s.				
United States	40 401	4 384	56 142	5 270
United Kingdom	2 647	697	210	8
Japan	366	58	310	44
West Germany	80	22	27	15
Italy	5	1	45	10
France	-	-	-	-
Netherlands	6	11	-	-
Other countries	-	-	5	1
Total	43 505	5 173	56 739	5 348
Total cement imports	286 927	24 177	475 267	31 808
Cement and concrete basic products, n.e.s.				
United States	..	4 217	..	6 674
United Kingdom	..	149	..	20
West Germany	..	110	..	148
Italy	..	6	..	90
Netherlands	..	4	..	22
Other countries	..	69	..	16
Total	..	4 555	..	6 970
Cement clinker				
France	24 308	709	26 297	1 124
Greece	29 806	1 143	31 506	1 122
Spain	148 827	5 575	30 210	1 109
Cyprus	-	-	22 536	978
United States	85	3	339	10
Other	-	-	-	-
Total	203 026	7 430	110 888	4 343

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Producers' shipments plus quantities used by producers. [2] Includes amounts of clinker and other cement.

.. Not available; - Nil; n.e.s. Not elsewhere specified; x Confidential.

TABLE 1B. CANADA, CEMENT PRODUCTION AND TRADE, 1988P

		1988P	
		(tonnes)	($000)
Production[1]			
By province			
Ontario		5 540 750	449 025
Quebec		3 394 000	194 850
Alberta		1 152 500	126 545
British Columbia		1 511 700	106 133
Manitoba		x	46 217
Nova Scotia		x	58 232
Saskatchewan		x	16 774
Newfoundland		x	10 791
New Brunswick		x	4 058
Total		12 610 550	1 012 625
Imports		**(Jan.-Sept.)**	
2523.10	Cement clinker		
	United States	1 748	37
	Other countries	172 468	6 128
	Total	174 216	6 165
2523.21	Portland cement, white whether or not artificially coloured		
	United States	4 389	471
	Other countries	2 714	424
	Total	7 103	895
2523.29	Portland cement, n.e.s.		
	United States	205 615	13 121
	Other countries	274 441	10 029
	Total	480 056	23 150
2523.30	Aluminous cement		
	United States	..	4 593
	Other countries	..	71
	Total	..	4 664
2523.90	Hydraulic cement, n.e.s.		
	United States	24 034	3 212
	Other countries	5 038	149
	Total	29 072	3 361
6810.11	Building blocks and bricks of cement, concrete or artificial stone		
	United States	..	6 632
	Total	..	6 632
6810.19	Tiles, flagstones and similar articles of cement/concrete or artificial stone		
	United States	..	1 995
	Other countries	..	2 274
	Total	..	4 269
6810.20	Pipes of cement or concrete		
	United States	..	6
	Total	..	6
6810.91	Prefabricated structural components of buildings, etc. of cement/concrete, etc.		
	United States	..	526
	Other countries	..	30
	Total	..	556

TABLE 1B. (cont'd)

		1988P Jan.-Sept.	
		(tonnes)	($000)
Imports (cont'd)			
6810.99	Articles of cement, of concrete or of artificial stone, n.e.s.		
	United States	..	1 425
	Other countries	..	103
	Total	..	1 528
Exports			
2523.10	Cement clinker		
	United States	285 667	9 900
	Total	285 667	9 900
2523.21	Portland cement, white whether or not artificially coloured		
	United States	60 475	7 926
	Other countries	2 408	283
	Total	62 883	8 209
2523.29	Portland cement, n.e.s.		
	United States	2 057 678	70 187
	Other countries	1 990	173
	Total	2 059 668	70 360
2523.30	Aluminous cement		
	United States	399	115
	Other countries	9	8
	Total	408	123
2523.90	Hydraulic cement, n.e.s.		
	United States	473 595	20 147
	Other countries	643	194
	Total	474 238	20 341
6810.11	Building blocks and bricks of cement, concrete or artificial stone		
	United States	..	2 303
	Other countries	..	138
	Total	..	2 441
6810.19	Tiles, flagstones and similar articles of cement/concrete or artificial stone		
	United States	..	4 146
	Other countries	..	794
	Total	..	4 940
6810.20	Pipes of cement or concrete		
	United States	..	704
	Other countries	..	1 632
	Total	..	2 336
6810.91	Prefabricated structural components of buildings, etc. of cement/concrete, etc.		
	United States	..	27 484
	Other countries	..	2 611
	Total	..	30 095
6810.99	Articles of cement, of concrete or of artificial stone, n.e.s.		
	United States	..	3 190
	Other countries	..	130
	Total	..	3 320

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Producers' shipments plus quantities used by producers.

P Preliminary; .. Not available; n.e.s. Not elsewhere specified; x Confidential.

TABLE 2. CEMENT PLANTS, APPROXIMATE ANNUAL GRINDING CAPACITY, END OF 1987[r]

Company	Plant	Wet(W) Dry(D) Pre-heater(x) Precal-ciner(c)	Fuel (Coal Oil Gas)	No. of Kilns	Grinding Capacity (000 t/y)	Clinker Capacity (000 t/y)
Atlantic						
Lafarge Canada Inc.	Brookfield, N.S.	D	C,O	2	485	458
	Havelock, N.B.				315	-
North Star Cement Limited	Corner Brook, Nfld.	Dx	O	1	315	152
Atlantic Region Total				3	1 115	610
Quebec						
Lafarge Canada Inc.	Montreal East				600	-
Lafarge Canada Inc.	St. Constant	D	C,O,G	2	955	902
Ciment Québec Inc.	St. Basile	W, Dc	O	3	8 301	1 106
St. Lawrence Cement Inc.	Beauport	W	C	2	505	598
(Independent Cement Inc.)	Joliette	D	C,O	4	1 075	992
Quebec Region Total				11	3 965	3 598
Ontario						
Lafarge Canada Inc.	Woodstock	W	C,G	2	535	505
	Bath	Dx	C,G	1	1 000	943
Federal White Cement Ltd.	Woodstock	D	O,C,G	1	177	147
Lake Ontario Cement Limited	Picton	D, Dx	C,G	4	861	1 422
St. Lawrence Cement Inc.	Mississauga	W, Dc	C,O,G	3	1 600	1 860
St. Marys Cement Company	Bowmanville	W	C	2	788	600
	St. Marys	W, Dx	G,C	3	800	991
Ontario Region Total				16	5 761	6 468
Prairies						
Lafarge Canada Inc.	Fort Whyte, Man.				565	-
	Exshaw, Alta.	D, Dc	G,C	3	1 230	1 184
Inland Cement Limited-(CBR)	Winnipeg, Man.	W	O,G	1	431	413
	Regina, Sask.	D	O,G	1	375	218
	Edmonton, Alta.	W, Dc	G	1	1 500	702
Prairies Region Total				6	4 101	2 517
British Columbia						
Lafarge Canada Inc.	Kamloops	D	G	1	190	180
	Richmond	W	C,G	2	555	522
Tilbury Cement Limited-(CBR)	Tilbury Island	Dx	C,G	1	900	875
B.C. Region Total				4	1 645	1 577
Canada Total (9 companies)				40	16 587	14 770

Source: Market and Economic Research Department, Portland Cement Association.
- Nil; [r] Revised.

TABLE 3. CANADA, CEMENT PLANTS, KILNS AND CAPACITY UTILIZATION, 1977-88

	Clinker Producing Plants	Kilns	Approximate Cement Grinding Capacity[1] (t/y)	Portland and Masonry Cement Production[2] (t)	Clinker Exports[3] (t)	Approximate Total Production[4] (t)	Capacity Utilization (%)
1977	22	49	14 885 000	9 639 679	775 145	10 414 824	72
1978	24	51	15 985 000	10 558 279	1 077 274	11 635 553	72
1979	24	51	15 985 000	11 765 248	1 530 537	13 295 785	83
1980	23	47	16 363 000	10 274 000	726 087	11 000 087	67
1981	23	48	16 771 000	10 145 000	524 006	10 669 006	64
1982	23	48	16 771 000	8 418 000	290 329	8 708 329	50
1983	23	49	17 900 000	7 870 878	404 793	8 275 671	46
1984	23	49	17 900 000	9 387 466	440 297	9 827 763	55
1985	23	49	17 900 000	10 192 442	676 596	10 869 038	61
1986	23	49	17 900 000	10 611 223	324 000	10 935 223	61
1987r	20	40	16 600 000	12 603 164	767 338	13 370 502	81
1988p	20	40	16 600 000	12 610 550	380 000e	12 990 550	78

Sources: Statistics Canada; U.S. Bureau of Mines; Portland Cement Association (PCA).
[1] Includes three plants that grind only. [2] Producers' shipments and amounts used by producers. [3] Imports to United States from Canada. [4] Cement shipments plus clinker exports.
e Estimated; p Preliminary; r Revised.

TABLE 4. CANADA, HOUSE CONSTRUCTION, BY PROVINCE, 1986 AND 1987

	Starts			Completions			Under Construction		
	1986	1987	% Diff.	1986	1987	% Diff.	1986	1987	% Diff.
Newfoundland	2 883	2 682	-7.0	2 400	2 836	18.2	3 823	3 631	-5.0
Prince Edward Island	1 110	933	-16.0	1 176	943	-19.8	362	338	-6.6
Nova Scotia	7 571	6 460	-14.7	7 571	6 488	-14.3	3 435	3 283	-4.4
New Brunswick	4 045	3 716	-8.1	4 504	3 944	-12.4	1 770	1 524	-13.9
Total (Atlantic Provinces)	15 609	13 791	-11.6	15 651	14 211	-9.2	9 390	8 776	-6.5
Quebec	60 348	74 179	22.9	56 984	68 949	21.0	24 531	28 974	18.1
Ontario	81 470	105 213	29.1	69 567	88 609	27.4	48 625	64 458	32.6
Manitoba	7 699	8 174	6.2	7 341	7 627	3.9	4 178	4 765	14.0
Saskatchewan	5 510	4 895	-11.2	5 072	5 640	11.2	3 255	2 457	-24.5
Alberta	8 462	10 790	27.5	9 172	9 334	1.8	2 913	4 331	48.7
Total (Prairie Provinces)	21 671	23 859	10.1	21 585	22 601	4.7	10 346	11 553	11.7
British Columbia	20 687	28 944	39.9	20 818	23 606	13.4	8 548	13 986	63.6
Total Canada	199 785	245 986	23.1	184 605	217 976	18.1	101 440	127 747	25.9

Source: Canada Mortgage and Housing Corporation.

TABLE 5. CANADA, VALUE OF CONSTRUCTION[1] BY TYPE, 1986-88

	1986	1987	1988
		($ millions)	
Building Construction			
Residential	28 885	36 003	35 651
Industrial	3 201	3 189	3 339
Commercial	10 119	12 068	13 097
Institutional	3 565	4 172	4 202
Other building	1 656	1 796	1 987
Total	47 427	57 228	58 277
Engineering Construction			
Marine	335	361	489
Highways, airport runways	5 192	5 065	5 284
Waterworks, sewage systems	2 377	2 294	2 553
Dams, irrigation	243	248	287
Electric power	3 370	3 625	4 443
Railway, telephones	2 753	2 954	3 024
Gas and oil facilities	6 728	5 917	7 490
Other engineering	3 275	3 164	3 432
Total	24 274	23 628	27 002
Total construction	71 701	80 856	85 279

Source: Statistics Canada.

[1] Actual expenditures 1986, preliminary actual 1987, intentions 1988.

TABLE 6. CANADA, VALUE OF CONSTRUCTION[1] BY PROVINCE, 1986-88

	1986			1987			1988		
	Building Construction	Engineering Construction	Total	Building Construction	Engineering Construction	Total	Building Construction	Engineering Construction	Total
					($000)				
Newfoundland	802 442	809 153	1 611 595	878 732	696 895	1 575 627	898 710	664 234	1 562 944
Nova Scotia	1 493 407	872 077	2 365 484	1 694 516	715 721	2 410 237	1 752 532	785 781	2 538 313
New Brunswick	1 042 640	428 756	1 471 396	1 178 179	465 024	1 643 203	1 229 301	470 882	1 700 183
Prince Edward Island	223 287	70 364	293 651	222 907	72 148	295 055	241 763	86 388	328 151
Quebec	11 690 251	3 888 916	15 579 167	13 971 089	4 158 213	18 129 302	13 799 399	4 888 767	18 688 166
Ontario	19 480 274	5 824 510	25 304 784	24 148 448	6 061 990	30 210 438	24 509 690	6 807 027	31 316 717
Manitoba	1 870 090	928 101	2 798 191	1 992 684	942 052	2 934 736	2 033 533	1 154 802	3 188 335
Saskatchewan	1 563 702	1 396 406	2 960 108	1 808 053	1 502 338	3 310 391	1 792 538	1 732 571	3 525 109
Alberta	4 109 233	6 239 982	10 349 215	4 775 800	5 663 670	10 439 470	4 892 445	7 048 038	11 940 483
British Columbia, Yukon and Northwest Territories	5 151 540	3 815 498	8 967 038	6 557 677	3 349 923	9 907 600	7 126 702	3 363 932	10 490 634
Canada	47 426 866	24 273 763	71 700 629	57 228 085	23 627 974	80 856 059	58 276 613	27 002 422	85 279 035

Source: Statistics Canada.

[1] Actual expenditures 1986, preliminary actual 1987, intentions 1988.

Chromium

D.R. PHILLIPS

SUMMARY

The major markets for chromium continue to be the ferrochrome requirements of the stainless and alloyed steel industries. The consumption of ferrochrome in the western world in 1988 increased 6% over 1987, due mainly to increased demand for stainless steel.

Due to the increased demand in 1988 and 1987, 1988 prices for low carbon ferrochrome increased about 135% and "charge chrome" rose about 200% over 1986 prices.

South Africa is the western world's largest producer of chrome ore and ferrochrome, and accounts for 65% of western world supply.

Canada imports all of its chromium requirements, mainly in the form of high carbon ferrochrome and charge chrome.

Canada has not produced chromium ferroalloys since World War II because domestic ore grades were too low to permit economic upgrading. Although extensive deposits of chromium ores exist in the Eastern Townships of Quebec, and in Manitoba's Bird River area, little exploration could be justified, given the low price of chromium products. However, beginning in 1986 renewed exploration drilling has been prompted by increased prices and increased concerns about security of supply.

CANADIAN DEVELOPMENTS

Although Canada upgraded chrome ore from its reserves in the 1920s and 1940s, it currently has no mine production due mainly to the low grade of its ores. Increased exploration is expected, however, in response to stronger chromium ferroalloy prices. The international price for "charge chrome" has increased in the last 18 months from US38¢/lb. to US98¢/lb. and is forecast to remain at this high level into the medium term.

The deposits at Bird River, Manitoba and the Eastern Townships in Quebec have attracted new interest. Although in the past the potential for production appeared low, the development of these deposits for upgrading to intermediate or processed chromium products is being reexamined in view of new developments in plasma smelting, uncertainties over foreign supplies, the potential for low cost production in Canada due to attractive energy costs, and the recent sharp increases in prices.

In the Eastern Townships of Quebec, chromite minerals, which were exploited early in the century and during the Second World War, occur as discontinuous and podiform deposits. Although these deposits would be generally satisfactory in grade and composition for upgrading, they are not well defined and require further exploration and delineation to quantify the reserves.

Drilling by Gateford Resources Inc. and Macamic Resources Inc., initiated in 1986 to assess the potential to upgrade the chromite of the Reed-Belanger chromite property in the Eastern Townships, was completed in 1988. Preliminary assessment of the results appear to be more promising than originally projected for economical upgrading of the ore.

Exploration Rambo Inc. currently named Ressources Minières Coleraine Inc. started exploration as part of its Coleraine Project in Quebec in 1986, and continued through to 1988. The work consisted of mapping, trenching, geochemistry and gravimetric surveys. Rambo is part of Morisco Mining Group, the latter also includes Exploration Essor Inc. and Novéder Inc.

The currently preliminary exploration by Rambo is understood to have revealed a 15 km long chromite zone containing nickel, platinum and palladium. Current drilling in the Hall area of the deposit reports average ore grades of platinum group elements (PGE's) of 0.304 g/t and 7.7% Cr_2O_3 along

---

D.R. Phillips is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 992-1904.

15 m, equivalent to 1.5 Mt of reserves with economic potential for upgrading. Exploration of deeper zones indicates the possibility of further increasing the reserve estimates. Work to delineate this deposit will continue in 1989.

The more than doubling of chromium ferroalloy prices, together with legislation enacted by the provincial government in 1983 to separate land ownership from mineral rights, have resulted in new efforts to quantify Quebec's chrome resources. Land owners, in order to retain their mineral rights after 1983, had to stake claims on their properties and carry out a specified amount of exploration and development work each year in order to maintain their mineral rights.

As part of the Federal/Provincial Mineral Development Agreement, the Federal and Manitoba Governments initiated studies to further assess the economics of upgrading the Bird River chromite deposits. Other federally assisted studies to establish the potential to produce ferrochrome in Quebec and British Columbia have gained momentum not only because of continued escalation of chromium ferroalloy prices, but also because of the desire to develop value-added upgrading opportunities in Canada, since at present, Canada's ferrochrome is all imported.

Canadian consumption of chromium ferroalloys in 1988 was estimated at 38 000 t, virtually unchanged from the previous year. Canadian demand represents about 1.5% of total world consumption, which grew by almost 6% to a level of 2 950 000 t gross weight in 1988.

In addition, Canada consumes about 21 000 t/y of chromite ore. The major consumers are Canadian Refractories, division of Dresser Canada, Inc.; Didier Refractories Corporation; General Refractories Co. of Canada Ltd.; Kaiser Refractories Company, division of Kaiser Aluminum & Chemical Canada Investment Limited; Canadian Steel Foundries, division of Hawker Siddeley Canada Inc.; and Abex Industries Ltd.

The value of imports of all chromium-containing raw materials increased from $48.3 million in 1987 to an estimated $70.5 million in 1988. About $56 million of the total represents ferrochrome, 80% of which was used by the steel industry, with the remainder consumed by foundries.

Rio Algom Limited's steel facilities in Tracey, Quebec and Welland, Ontario is Canada's principal producer of stainless steel, and is the largest Canadian consumer of chromium ferroalloys. All Canadian users of chromium ferroalloys are dependent on imports. Currently about two-thirds of Canada's needs are sourced in South Africa.

The three Canadian producers of bulk ferroalloys (currently only alloys of manganese and silicon), are all located in Quebec. Timminco Metals, division of Timminco Limited located at Beauharnois, is adjacent to Elkem Métal Canada Inc., a division of Elkem a/s located on the shores of the St. Lawrence Seaway. The third bulk alloy producer is SKW Canada Inc., a subsidiary of SKW Trostberg AG. Its plant is located at Bécancour, Quebec with easy access to the Seaway.

The prospect for continued high prices for chromium ferroalloys, competitive Canadian energy rates, and a favourable exchange rate for the dollar are strong economic factors which could encourage investment in new chromium ferroalloy capacity in Canada. Current studies undertaken by a consortium consisting of Le Groupe SGF, SKW Canada Inc. and Mitsui & Co. (Canada), Ltd. indicate that based on current prices for chromium ferroalloys there is economical potential to smelt high carbon ferrochrome at Bécancour, Quebec. Production at the proposed Bécancour plant would utilize foreign and/or domestic ores. The smelter studies have evaluated upgrading of the ores by conventional and plasma smelting.

In addition to the Quebec studies, the federal and provincial governments and the private sector separately or jointly continue to quantify potential domestic chromite reserves and establish the economic feasibility of upgrading domestic and imported ores to produce chromium ferroalloys. For example, some of the work associated with the Bird River sill of Manitoba proposes that it is economically feasible to upgrade the ores to produce a semi-finished stainless "hot band". Additional work is required to quantify the chromite resources. British Columbia is also a suitable location to produce chromium ferroalloys, but would probably utilize imported chrome ores. The province has competitive electricity rates and excellent shipping facilities.

WORLD DEVELOPMENTS

Chromium consumption is directly linked to the demand for stainless and specialty steels and for applications in the ferrous foundry industry, chemicals and other metallurgical industries. The demand for chromium ferroalloys increased in 1986 through 1988, in line with the strong recovery in stainless and specialty steel production and partly due to uncertainties about supplies from South Africa and the Philippines. These factors created a tight market in 1987 and 1988, with prices sharply higher in 1988 to nearly US$1/lb. for charge chrome.

The sustained demand during 1986-88 in the European Economic Community (EEC), the United States and Japan was derived mainly from consumption of chromium in the automotive and other transportation sectors, and in the building sectors. The latter was characterized by substantial plant modernizations, expansions and the building of new facilities.

This increase in demand created a production deficit in 1987 and 1988 of 200 000 t/y on average, which was supplemented by withdrawal from stocks. This situation is expected to continue until additional capacity is brought on-stream.

Western world consumption in 1988 is estimated at 1.62 Mt of contained chromium, which represents an increase of 6% over the previous year, and the highest level since 1982. The EEC is the largest consumer, and largest importer of ferrochromium. Japan and the United States are the other major consumers.

Total western world output of chromium ferroalloys in 1988 was estimated at 2.71 Mt, gross weight or 1.49 Mt of contained chromium. Capacity utilization in 1988 was estimated at 95% compared to 89% in 1987. All of the world's producers of ferrochromium increased their production in 1988 except Albania, as it was already operating at capacity in 1987.

Plans to bring additional new capacity into production in South Africa, Zimbabwe, Finland, China, Italy, Brazil and Albania could begin to contribute in 1989, when some 75 000 t of output could be achieved. Most of the increase will be in South Africa, the world's largest producer of chrome ore and chromium ferroalloys. It is a natural location to add capacity due to its extensive resources of high grade ore and the fact that South Africa is a leader in mining exploration and chromium ferroalloy smelting.

In the longer term, planned new capacity could result in an eventual gain, net of closures, estimated at 563 000 t gross weight by 1993. Of this, South Africa would account for 255 000 t. Most of this total new capacity is expected to be operational by 1991, although there is about 115 000 t of capacity additions in Zimbabwe, the People's Republic of China and Albania that is subject to possible delay.

The problem in Zimbabwe is related to its plans to complete a new railroad which may take until 1993.

The newly imposed tax of 20% by China on the exports of ferroalloy could also lead to a rescheduling of capacity additions.

As noted, the production of chromium ferroalloys in the western world was marginally below consumption during the last two years. Although demand was firm and prices increased throughout 1988, producers were limited in their scope to take advantage of the stronger market, mainly because they were approaching their capacity limitations and, to a lesser degree, because of a scarcity of chrome ore.

In terms of mine production of chromium ores for all uses, including refractories and chemicals, the western world produced 7.8 Mt in 1988 compared to 7.5 Mt in 1987. In terms of contained chromium, these annual figures convert to 2.96 Mt and 2.85 Mt, respectively. The utilization of mine capacity rose from 74% in 1986 to 85% in 1987 and to 95% in 1988. In spite of this improvement, aggregate mine production during these two years fell short of total western world consumption for all uses by about 200 000 t. The western world mine producers, excluding the Lesser Developed Countries (LDC's), accounted for 41% of world production, the LDC's 22% and the Communist Bloc countries 37%.

In the United States, the Macalloy Inc. facility at Charleston, South Carolina continued to upgrade chrome ore from the U.S. strategic stockpile in 1988. The upgrading program is part of a barter agreement between the U.S. General Services Administration (GSA) and Macalloy. Macalloy receives tungsten ores and concentrates from the U.S. stockpile as payments. Although the program was initiated in 1982 by a directive from President Reagan as part of a U.S. plan to sustain ferroalloy production for defence purposes, the conversion did not begin until 1984. An additional upgrading program was authorized for the conversion of stockpiled chromite to 374 000 t of high carbon ferrochromium.

Swedechrome AB of Sweden started operating the world's first commercial plasma ferrochrome plant in March 1987. The technology was developed by SKF Steel AB. The company's plans called for reaching maximum capacity of 80 000 t/y of high carbon ferrochrome by year end. The company is reported to be currently operating at about 80% of capacity. Continued successful operation could accelerate the closure of obsolete smelters and further encourage the trend to increased smelting in countries with high grade ores and competitive electricity rates.

China imports chrome ore for the production of its ferrochromium. The main suppliers are India and Turkey. It was estimated that China exported about 6 000 t of surplus ferrochromium to Japan in 1987 and consumed the remainder. China's ferrochromium capacity is estimated at 181 000 t/y. It is expected to increase to 375 000 t/y by 1993, in response to increased domestic demand.

USES

While many minerals contain chromium, chromite is the only commercial ore mineral. The theoretical formula for chromite is $FeCr_2O_4$, although it usually contains several other elements. Traditionally, chromite ores have been classified as metallurgical, chemical and refractory grades, according to the expected industrial end uses. However, recent technological advances have allowed some degree of interchange in the usage of these three product categories with the result that the classification has become less meaningful. Current nomenclature is based upon chromite composition in addition to end-use. High chromium ores, defined by high Cr/Fe ratios, are used for making ferrochromium for metallurgical applications. High iron chromites, previously limited almost entirely to the production of chromium-based chemicals, are now finding growing usage in the production of low quality ferrochromium, refractories and foundry sands. High aluminum chromites with relatively low iron and silica have application mainly for refractory purposes, primarily in the manufacture of magnesite-chromite and chromite-magnesite brick.

The principal use of chromium ferroalloys is in the production of stainless and heat-resistant steels. Most applications of stainless and heat-resistant steels are in corrosive environments such as petrochemical processing, high temperature environments such as turbines and furnace parts, and consumer goods such as cutlery and decorative trim. Chromium is added to alloy and tool steels to increase their hardening ability and to improve mechanical properties such as yield strength. Superalloys containing chromium have a high degree of resistance to oxidation and corrosion at elevated temperatures and are used in jet engines, gas turbines and chemical process equipment. Chromium-containing castings are usually used in high temperature applications.

Increased consumption in the automotive sector has been created by automakers marketing options that include extra chrome trim, longer warranties, increased use of stainless steel for catalytic converters, radiator caps and other control and decorative systems.

Chromium consumption has also increased due to its use in aircraft engines and other aerospace applications, which require chromium superalloys because of their high heat resistance.

The refractory industry uses chromite in the manufacture of refractory bricks, castables, mortars and ramming gun mixes. Chromite castables, mortars and gunning mixes are used for repairs and in the bonding and coating of basic bricks, and in areas where the separation of various types of bricks by a chemically neutral substance is desirable.

Refractories containing both chromite and magnesite are used in furnaces wherever basic slags and dust are encountered, such as in the ferrous and nonferrous metal industries. In the ferrous industry, chromite-magnesite brick is used in basic open hearth furnaces and electric furnaces. The phasing out of open hearth furnaces has led to a decline in the amount of chromite used as a refractory in the steel industry. However, this trend has been offset to a certain extent by an increase in electric furnace production and, overall, chromite refractory consumption in the steel industry is expected to remain stable during the next few years. In the nonferrous metals industry, chromite magnesite brick is used mainly in converters. The increasing use of oxygen in oxygen-blowing converters, resulting in higher operating temperatures, has changed refractory requirements to a higher magnesite-content brick, thereby decreasing the consumption of chromite in this application. The glass industry uses chromite-magnesite brick in the reheating chambers of glass furnaces, while the kraft paper industry requires a dense chromite brick in recovery furnaces to resist chemical attack by spent pulping liquors.

OUTLOOK

Following the escalation of prices for charge chrome from US38¢/lb. to a high of US98¢/lb. in November 1988, prices are forecast to remain in the US90¢/lb. range in the short term. The firmness will result from a forecasted increase in consumption estimated at about 100 000 t/y until 1991. Coinciding with this increase is a projected production deficit of about 100 000 t/y on average.

When new capacity additions of some 350 000 t is brought into production during the next year or two, supply will be boosted to 3.2 Mt/y of chromium ferroalloy and a supply/demand balance should be attained.

Further new capacity planned for 1992 could, however, result in some price softening, but it is unlikely that prices will fall below 85¢/lb., since forecasted consumption of chromium ferroalloy is expected to remain in the range of 3 Mt/y throughout the period 1992-95.

PRICES

Chromium prices published by **Metals Week**	December 29, 1986	December 25, 1987	December 25 1988
		(US$)	
Chrome ore, dry basis, f.o.b. shipping point			
Transvaal 44% Cr_2O_3, no ratio (per tonne)	40.00-42.00	40.00-46.00	50.00-56.00
Turkish 48% Cr_2O_3, 3:1 ratio (per tonne)	125.00	115.00	150.00-158.00
Chromium metal, U.S. electrolytic			
Electrolytic 99.1% Cr, f.o.b. shipping point (per kg)	6.92-8.29	6.95-8.29	8.29
		(US¢)	
Ferrochromium, f.o.b. shipping point (per kg Cr content)			
Imported 50-55% charge chrome	84.53-85.63	128.18-136.60	194.48-205.53
Imported 60-65% charge chrome	91.70-95.58	136.60-143.65	205.53-214.37
MW, Imported low carbon, 0.05%C	183.43-187.85	221.00-232.05	265.20-278.46

f.o.b. - Free on board.

Item No.	Description	Canada			United States	EEC	Japan[1]
		MFN	GPT	USA[1]	Canada	MFN	MFN
2610.00.00	Chromium ores and concentrates	Free	Free	Free	Free	Free	Free
2610.00.00.10	-----Refractory grade	Free	Free	Free	Free	Free	Free
2610.00.00.90	-----Other (chrome content)	Free	Free	Free	Free	Free	Free
2819.10.00.00	-Chromium trioxide	12.5%	8%	10%	2.9%	13.4%	4.9%
2819.90.00.00	-Other	12.5%	8%	10%	2.9%	13.4%	4.9%
28.33	Sulphates; alums; peroxosulphates (persulphates)						
2833.23	--of chromium						
2833.23.10.00	---Chromium sulphate, basic	Free	Free	Free	2.9%	9%	4.9%
2833.23.90.00	---Other chromium sulphates	9.2%	6%	7.3%	2.9%	9%	4.9%
	-Chromium ferroalloys						
7202.41.00.00	--Containing by weight more than 4% of carbon	10.2%	6.5%	Free	Free	8%	8%
7202.49.00.00	--Other	10.2%	6.5%	Free	Free	8%	8%
7202.50.00	-Silico-chromium ferroalloys	10.2%	6.5%	Free	Free	8%	3.7%

Sources: Customs Tariffs, effective January 1989, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States (First Edition Supplement 2) effective January 1, 1989; Official Journal of the European Communities, Vol. 30, No. L256, 1987, "Conventional" column; Custom Tariff Schedules of Japan, 1988.

[1] GATT rate is shown, lower tariff rates may apply circumstantially.

TABLE 1A. CANADA, CHROMIUM IMPORTS, 1985-87

	1985		1986		1987	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Chromium in ores and concentrates						
United States	3 909	1 306	5 931	1 729	6 116	2 077
Philippines	1 581	730	3 336	1 436	4 059	1 810
Cuba	961	445	1 040	492	1 179	511
Fr. Polynesia	-	-	1 539	569	1 004	415
South Africa	2 749	614	4 128	1 159	1 187	244
Turkey	2 124	597	-	-	-	-
Total	11 324	3 692	15 974	5 384	13 545	5 057
Ferrochromium						
South Africa	17 241[r]	11 779	20 010	14 902	25 475	16 290
United States	6 525	7 132	7 937	7 990	14 117	13 969
Finland	109	77	3 846	2 713	1 816	1 296
Belgium-Luxembourg	-	-	-	-	1 500	960
Zimbabwe	-	-	-	-	995	761
Sweden	496	877	598	1 031	218	414
Greece	-	-	5 000	3 756	-	-
Yugoslavia	2 800	2 584	1 631	931	-	-
Turkey	1 100	847	23	20	-	-
Total	28 271[r]	23 297	39 045	31 343	44 121	33 690
Chromium sulphates, including basic (gross weight)						
West Germany	184	160	446	415	516	496
United Kingdom	693	525	622	512	602	456
United States	70	84	32	29	119	155
Mexico	-	-	20	13	149	104
Italy	18	18	-	-	-	-
Total	965	769	1 120	969	1 386	1 210
Chromium oxides and hydroxides (gross weight)						
United States	1 108	2 862	1 222	3 507	1 305	3 589
West Germany	404	1 130	780	2 136	846	2 070
United Kingdom	371	926[r]	361	983	456	1 844
U.S.S.R.	20	40	20	43	217	396
Netherlands	-	-	17	36	50	124
Belgium-Luxembourg	-	-	25	87	36	98
Italy	72	139	35	84	36	90
Japan	16	32	16	34	34	82
Denmark	-	-	-	-	1	7
Chile	18	44	-	-	-	-
Total	2 009	5 173	2 476	6 910	2 981	8 301

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[r] Revised; - Nil.

Note: Components may not add due to rounding.

TABLE 1B. CANADA, CHROMIUM IMPORTS, 1988P

Item No.		1988P Jan.-Sept.	
		(tonnes)	($000)
2610.00.00.00	Chromium ores and concentrates		
	United States	5 237	1 577
	Philippines	4 045	940
	Cuba	3 804	516
	South Africa	3 834	378
	New Caledonia	1 792	329
	Total	18 711	3 740
28.19	Chromium oxides and hydroxides		
2819.10.00.00	-Chromium trioxide		
	United States	696	1 694
	West Germany	593	1 542
	United Kingdom	451	1 404
	Italy	57	150
	Netherlands	...	47
	Belgium	...	45
	Total	1 796	4 882
2819.90.00.00	-Other		
	United States	2 219	2 245
	United Kingdom	116	243
	Romania	139	119
	West Germany	103	102
	Total	2 576	2 709
28.33	Sulphates; alums; peroxosulphates (persulphates)		
2833.23	--of chromium		
	United Kingdom	651	616
	United States	312	434
	Mexico	241	185
	West Germany	128	122
	Total	1 331	1 357
72.02	Ferroalloys		
	-Ferrochromium		
7202.41.00.00	--Containing by weight more than 4% of carbon		
	South Africa	23 637	20 141
	United States	4 816	5 749
	Finland	2 001	1 708
	Zimbabwe	1 085	1 112
	Greece	190	190
	Yugoslavia	86	105
	Philippines	40	73
	Total	31 854	29 078
7202.49.00.00	--Other		
	United States	2 657	3 912
	South Africa	2 769	3 415
	Zimbabwe	304	534
	West Germany	107	269
	Yugoslavia	5	11
	Total	5 842	8 141
7202.50.00.00	-Ferrosilico-chromium		
	United States	1 516	1 876
	South Africa	520	401
	Zimbabwe	200	266
	Total	2 237	2 543

Sources: Energy, Mines and Resources Canada; Statistics Canada.
P Preliminary; ... Too small to be expressed.

TABLE 2. CANADA, CHROMIUM TRADE 1970, 1975, 1980-88

	Imports	
	Chromite (Chromium content)	Chromium Ferroalloys
	(tonnes)	
1970	27 619	20 814
1975	29 663	41 109
1980	28 373	41 369
1981	47 626	31 573
1982	8 053	21 783
1983	9 759	32 559
1984	11 927	33 092
1985	11 324	28 271^{r}
1986	15 974	39 045
1987	13 545	44 121
1988^{e}	16 500	42 000

Sources: Statistics Canada; Energy, Mines and Resources Canada.
^{r} Revised; ^{e} Estimated.

TABLE 2A. CANADA, CHROMIUM CONSUMPTION, 1970, 1975, 1980-88

	Consumption[1]	
	Chromite	Ferrochromium
	(tonnes)	
1970	56 212	28 356
1975	36 790	18 417
1980	27 900	30 175
1981	24 771	29 547
1982	15 330	18 393
1983	15 682	23 741
1984	21 059	28 524
1985	17 555	21 856
1986	20 935	33 185
1987^{p}	18 569	37 227
1988^{e}	21 000	38 000

Source: Energy, Mines and Resources Canada.
[1] Available data as reported by consumers.
^{p} Preliminary; ^{e} Estimated.

TABLE 3. CANADA, FERROCHROMIUM IMPORTS, 1985-88

Grade	1985	1986	1987	1988^{e}
		(tonnes, gross weight)		
High Carbon Ferrochrome (over 2%C)	9 764	14 728	24 641	23 740
Low Carbon Ferrochrome (max. 2%)	1 942^{r}	3 580	3 987	3 780
Charge Chrome	12 941	18 695	12 963	12 180
Silicon Ferrochrome	2 402	1 887	2 295	2 100
Ferrochrome n.e.s.	1 212	148	232	200
Total	24 266^{r}	39 039	44 118	42 000

Sources: Energy, Mines and Resources Canada; Statistics Canada.
^{r} Revised; ^{e} Estimated; n.e.s. Not elsewhere specified.
Note: Components may not add due to rounding.

TABLE 4. ESTIMATED WORLD CHROMIUM FERROALLOY CAPACITY, 1988, 1990 AND 1993

Country	1988	1990	1993
	(000 tonnes)		
South Africa	1 120	1 250	1 375
U.S.S.R.	475	475	475
Japan	413	350	300
India	280	350	375
Sweden	243	350	375
United States	140	140	140
Zimbabwe	258	325	325
People's Republic of China	181	200	375
Finland	150	175	175
Brazil	135	160	160
Turkey	130	160	160
Yugoslavia	130	130	130
Italy	72	145	145
Philippines	70	95	95
France	50	50	50
Greece	38	65	65
Spain	35	135	135
Albania	35	65	65
Norway	17	17	17
Mexico	8	8	8
Other	24	30	40

Sources: Energy, Mines and Resources Canada; Resource Strategies, Inc., Chromium Industry Analysis 1988, Tex Ferroalloy Manual 1987, Roskill Economics of Chromium 1988.

TABLE 5. WORLD CHROMITE MINE PRODUCTION, 1987 AND 1988 AND CHROME ORE RESERVES

	Mine Production		Chrome Ore Reserves
Country	1987	1988e	1988
	(000 tonnes, gross weight)		
Republic of South Africa	4 175	4 375	913 000
U.S.S.R.	3 470	3 470	142 000
Albania	915	915	7 000
Finland	785	785	19 000
Turkey	660	667	5 000
Zimbabwe	595	650	19 000
India	575	675	15 000
Brazil	250	300	9 000
Philippines	190	220	15 000
Cuba	135	150	..
Madagascar	110	110	..
Greece	70	70	..
New Caledonia	68	68	..
Other market economy countries	100	24	17 000

Sources: U.S. Bureau of Mines, Mineral Commodity Summaries 1988; Energy, Mines and Resources Canada.
e Estimated; .. Not available.

TABLE 6. WESTERN WORLD INCLUDING ALBANIA SUPPLY AND CONSUMPTION OF CHROMIUM FERROALLOYS GROSS WEIGHT AND AVERAGE ANNUAL PRICE

					Surplus/Deficit		Average
Year	Production	Producer Stocks	Total Supply	Consumption	Annual	Accumulated	Annual Price[1],[2]
		(000 tonnes)					(chromium content)
1982	1 903	50	1 953	1 872	81	81	99.45
1983	2 079	175	2 254	1 945	309	390	81.77
1984	2 552	100	2 652	2 380	272	662	95.03
1985	2 633	0	2 633	2 310	323	985	97.24
1986	2 642	0	2 642	2 575	67	1 052	86.19
1987	2 563	0	2 563	2 793	-230	882	97.24
1988	2 713	50	2 763	2 951	-188	634	209.95
1989e	2 813	50	2 863	2 900	-37	597	198.90
1990e	2 813	100	2 913	3 100	-187	440	198.90
1991e	2 913	150	3 063	3 150	-87	323	232.05

Sources: Energy, Mines and Resources Canada; U.S. Bureau of Mines, Mineral Commodity Summaries, Roskill Economics of Chromium 1988.
[1] Price calculated from chromium prices published by "Metals Week." [2] Annual price ¢/kg.
e Estimated.

Clays

M.A. BOUCHER

Clays are a complex group of industrial minerals which are generally characterized by different mineralogies, occurrences and uses. They are all natural, earthy, fine-grained minerals of secondary origin; they are composed mainly of a group of hydrous aluminum phyllosilicates and may contain iron, alkalis and alkaline earths. The clay minerals, formed by the chemical weathering or alteration of aluminous minerals, are generally classified into four major groups based on detailed chemistry and crystalline structure - the kaolinite group, the smectite group (montmorillonite group of some usages), the clay-mica group and the chlorite group. Clay deposits suitable for the manufacture of ceramic products may include non-clay minerals such as quartz, calcite, dolomite, feldspar, gypsum, iron-bearing minerals and organic matter. The non-clay minerals may or may not be deleterious, depending upon individual amounts present and on the particular application for which the clay is intended.

The commercial value of clays, and of shales that are similar in composition to clays, depend primarily on their physical properties such as plasticity, strength, shrinkage, vitrification range and refractoriness, fired colour, porosity and absorption. Their economic value is also dependent upon their production and transportation costs, the level of competition and the potential for substitution.

USES, TYPE AND CANADIAN DEPOSITS

Common Clays and Shales. Common clays and shales are the principal raw materials available from Canadian deposits for the manufacture of structural clay products. They are found in all parts of Canada, but deposits having excellent drying and firing properties are generally scarce and new deposits are continually being sought.

The clay minerals found in common clays and shales are chiefly illitic or chloritic. The material is sufficiently plastic to permit molding and vitrification at a low temperature. Suitable common clays and shales are utilized in the manufacture of structural clay products such as common brick, facing brick, structural tile, partition tile, conduit tile and drain tile. There are no specifically recognized grades of common clay and shale. Specifications are usually based upon the physical and chemical tests of manufactured products. The raw materials utilized in the structural clay industry usually contain up to 35% quartz. If the quartz, together with other non-plastic materials, exceeds this percentage, the plasticity of the clay and the quality of the ware are reduced. If calcite or dolomite is present in sufficient quantities, the clay will fire buff and the fired strength and density will be adversely affected.

Most of the surface deposits of common clays in Canada are the result of continental glaciation and subsequent stream transport. Such Pleistocene deposits are of interest to the ceramic industry and include stoneless marine and lake sediments, reworked glacial till, interglacial clays and floodplain clays.

In eastern Canada, shales are also consumed in large quantities for manufacturing cement near Corner Brook in western Newfoundland, and at Havelock in Kings County, New Brunswick. Common clay from glacial drift is used in Ontario as a source of silica and alumina in the manufacture of grey portland cement at Woodstock and St. Mary's. In Manitoba, shales and clays from glacial Lake Agassiz are extracted to produce lightweight aggregates. In Alberta, local glacial clays from Regina are used for manufacturing cement, lightweight aggregates and mineral wool insulation. In British Columbia, altered volcanic ash is extracted at Barnhartvale for cement, and in Quesnel

---

M.A. Boucher is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 992-3074.

mainly for use in manufacture of refractory materials. Common clay is also extracted from Sumas Mountain near Abbotsford to produce flue lining, drain pipe, bricks and blocks.

China Clay (Kaolin). China clay is a white clay composed mainly of kaolinitic minerals formed from weathered igneous rocks. Some deposits occur in sedimentary rocks as tabular lenses and discontinuous beds or in rocks that have been hydrothermally altered. Commercial china clays are beneficiated to improve their whiteness when used as fillers and their whitefiring characteristics when used in ceramics.

Several occurrences of kaolin in Canada have attracted attention. In British Columbia, a deposit of clay, similar to a secondary kaolin, occurs along the Fraser River near Prince George. Another kaolinitic deposit occurs at Lang Bay, near the Powell River.

In Saskatchewan, the Whitemud formation of southern Saskatchewan includes thick beds of kaolinitic sand. The kaolinite content locally is as much as 50%.

In Manitoba, various kaolinitic-rock deposits have been reported at Arborg, on Deer Island (Punk Island) and Black Island on Lake Winnipeg, and in the northwest at Cross Lake and Pine River; the Swan River Formation has also been investigated as a potential source of kaolin.

In Ontario, extensive deposits of kaolin-silica sand mixtures occur along the Missinaibi and Mattagami rivers southwest of James Bay in northern Ontario. Kaolinite is the major clay mineral; it is generally well crystallized and is dominant in the minus 2 microns. Minor amounts of quartz, chlorite and illite are usually present.

In Quebec, kaolin deposits have been actively mined in the past as a coproduct of a silica operation, near St-Rémi-d'Amherst, in Papineau County. Occurrences near Château-Richer in Montmorency County and Point-Comfort in Gatineau County have been studied as potential sources of kaolin for alumina, suitable for aluminous cement and refractories.

Ball Clay. Ball clay is defined as a fine-grained, highly plastic and mainly kaolinitic sedimentary clay. Natural colours range from white to brown, blue, grey and black, usually related to carbonaceous material. Fired colours may be white to offwhite. They are extremely refractory materials and have less alumina and more silica than kaolin. Ball clays occur in beds or lenticular units characterized by complex variations, both vertically and laterally.

Ball clays occurring in Canada are mineralogically similar to high-grade, plastic fire clay and are composed principally of fine-particle kaolinite, quartz and mica. These clays are known to occur in the Whitemud and the Ravenscrag Formations - Willowbunch Member - of southern Saskatchewan. Clay production takes place near Claybank, Eastend, Estevan, Flintoft, Readlyn, Rockglen, Willowbunch and Wood Mountain.

Fire Clay (Refractory Clay). Fire clay is a detrital clay mainly composed of kaolinite with a high content of alumina and silica. The mineral usually occurs in sedimentary rocks as lenticular bodies. These clays may range in plasticity from essentially that of ball clay to nonplastic varieties such as flint clay. They are formed by alteration of aluminous sediments deposited in a swampy environment or following transportation and concentration of clayey material.

Fire clay is used in the manufacture of products requiring high resistance to heat such as fire brick, insulating brick and refractory mortar. The refractory suitability is determined by the pyrometric cone equivalent (PCE) test. Canadian fire clays are used principally for the manufacture of medium- and high-duty fire brick and refractory specialties.

Various grades of good quality fire clay occur in the Whitemud Formation in southern Saskatchewan and on Sumas Mountain in British Columbia. Fire clay, associated with lignite as well as with kaolin-silica sand mixtures, occurs in the James Bay watershed of northern Ontario along the Missinaibi, Abitibi, Moose and Mattagami rivers. At Shubenacadie, Nova Scotia, some seams of clay are sufficiently refractory for medium-duty fire clay. Clay from Musquodoboit, Nova Scotia, has been used by some foundries in the Atlantic provinces, and the properties and extent of this clay were investigated by the Nova Scotia Department of Mines.

Stoneware Clay. Stoneware clays are intermediary between low-grade common clays and the high-grade kaolinitic clays. They are typically a mixture of kaolinitic and micaceous clay minerals. Stoneware clays must be capable of being fully vitrified at a relatively low temperature.

Stoneware clays are used extensively in the manufacture of sewer pipe, flue liners, and facing brick. They are widely used by amateur and studio potters.

The principal source of stoneware clay in Canada is the Whitemud Formation in southern Saskatchewan and southeastern Alberta. Stoneware clays also occur near Abbotsford on Sumas Mountain, at Chimney Creek Bridge, Quesnel and Williams Lake, British Columbia; near Swan River in Manitoba; and in Nova Scotia, at Musquodoboit and at Shubenacadie where it is used principally for manufacture of buff-facing bricks.

Bentonite and Fuller's Earth. Bentonite consists primarily of montmorillonite clay, and is formed from volcanic ash, tuff or glass, other igneous rocks, or from rocks of sedimentary origin. Sodium bentonite has strong swelling properties and possesses a high dry-bonding strength. Calcium bentonite of the non-swelling type usually exhibits greater adsorptive characteristics. Fuller's earth contains mainly smectite-group clay minerals and is very similar to non-swelling bentonite. It is formed by alteration of volcanic ash or by direct chemical precipitation of montmorillonite in shallow marine basins. Fuller's earth is characterized by adsorptive properties, catalytic action, bonding power and cation-exchange capacities.

Drilling Mud and Activated Clays. Drilling mud contains about 10% swelling bentonite. Synthetic bentonites may also be used for special muds. The swelling properties of a bentonite used as a drilling mud may be improved by adding soda ash in a drying process to substitute calcium cations with sodium cations. Activated clays are non-swelling bentonites that are acid-leached to remove impurities and to increase the reactive surface and bleaching power. They are used for decolouring mineral oils and as catalysts.

CANADIAN DEVELOPMENTS

In 1988, there was no commercial production of kaolin in Canada. However, three prospective producers located in Ontario, Saskatchewan and British Columbia are actively pursuing mine development for possible entry into the industry before the end of this decade. Consequently, all Canadian kaolin requirements were supplied by imports, mainly from Georgia and South Carolina. On a nine month basis in 1988, imports of kaolin and kaolinitic clays were 297 809 t. The value of imports in 1988 was $43.5 million and therefore unit value averaged $146.07.

Consumption of kaolin in 1987 was 310 241 t compared with 255 219 t in 1986. The pulp and paper industry accounted for 83% of total reported consumption, followed by ceramics, 3%; rubber, 3%; and paint and varnish, 2%.

In 1988, Fargo Resources Limited and Brenda Mines Ltd. continued their $3 million exploration program on the Lang Bay deposit in southern British Columbia. Recent drill tests from the deposit indicate 1 Mt of mineable reserves of white filler grade and grey cement grade kaolin. Ceramic grade brown kaolin was also identified. Internal marketing studies are being conducted by Noranda Sales Corporation Ltd.

In Saskatchewan, known deposits of sandy kaolinized clay with coloured fines occur near Fir Mountain, Flintoft, Knollys, and Wood Mountain. Ekaton Industries Inc. of Calgary acquired the rights on 18 000 ha of land in southern Saskatchewan to explore for kaolin in 1984. A study at the Wood Mountain kaolin deposit has been completed and a commercial process for the production of a premium quality kaolin paper filler has been delineated. More than 200 Mt of kaolin are contained in the deposit and the company is proposing to build a plant at Wood Mountain with an initial output of 150 000 t/y; capital costs are projected to be $30 million. A pilot plant was built in Regina during the year to upgrade the Wood Mountain ore. It was reported that a kaolin product with brightness in excess of 80 had been produced.

Ekaton through its 34% ownership in Chattaway Fine China Company Ltd. of Calgary is also studying the possibility of producing bone China, (a large consumer of kaolin) from its Wood Mountain deposit. A feasibility study is under way and the company estimates that a production facility would require an investment of about $9 million.

James Bay Kaolin Company, a subsidiary of Carlson Mines Ltd. of Toronto, is developing a kaolin-silica sand deposit near Smooth Rock Falls, southwest of James Bay in northern Ontario. Proven reserves have been estimated at 63 Mt of ore. A final feasibility study on a 2 750 t/d open-pit mine and processing plant was completed by Kilborn Limited in 1987. No new developments however were announced during 1988.

UNITED STATES PRODUCTION, CONSUMPTION AND MAJOR DEVELOPMENTS

Mine production of clays in the United States totalled 41.00 Mt in 1987; this compares with 40.47 Mt in 1986. Estimates for 1987 indicate that common clay accounted for 27.3 Mt; followed by kaolin, 8.07 Mt; bentonite, 2.36 Mt; fuller's earth, 1.77 Mt; ball clay, 0.84 Mt; and fire clay 0.58 Mt.

Apparent consumption of clays increased from 37.86 Mt in 1986 to an estimated 38.13 Mt in 1987. Domestic uses of specific clays in 1987 were as follows:

	% Consumption
Common clay	
Construction materials	95
Kaolin	
Paper	43
Refractories	7
Rubber	3
Ball clay	
Dinnerware and pottery	27
Sanitaryware	17
Floor and wall tile	14
Fire clay	
Fiberbrick	48
Foundry sands	10
Fuller's earth	
Absorbent	75
Insecticide dispersant	9
Bentonite	
Drilling mud	37
Foundry sand	22
Iron ore pelletizing	9

Engelhard Corporation, located in McIntyre and Gordon, Georgia, invested $80 million in an expansion program which added 270 000 t/y of kaolin to their existing operations capacity. The expansion included computerized process control systems and a new calciner. A large increase in the production of non-calcined products also resulted from the expansion.

PRICE QUOTATIONS FOR BALL CLAY AND KAOLIN

Chemical Marketing Reporter, December 1987-88.	US$ per short ton	
	1987	1988
Ball clay, f.o.b. Tennessee		
Airfloated, bags, carload	49.00	49.00
Crushed, moisture repellent, bulk carload	24.00	24.00
Kaolin, f.o.b. Georgia		
Dry-ground, airfloated, soft	38.00	52.00
Waterwashed, fully calcined, bags, carload: paint grade	260.00	305.00
paper grade	350.00	450.00
Waterwashed, uncalcined, delaminated paint grade, 1 micron average	240.00	282.00
Uncalcined, bulk, carload		
No. 1 coating	98.00	100.00
No. 2 coating	76.00	77.00
No. 3 coating	73.00	75.00
No. 4 coating	70.00	72.00
Filler, general purpose	58.00	64.00

Industrial Minerals, December 1987 (£1.00 = US$1.60-1.80); December 1988 (£1.00 = US$1.60-1.80)	£ per tonne	
	1987	1988
Ball clay, f.o.b. works		
Air dried, shredded, bulk	15-40	15-40
Refined, noodled, bulk	35-45	35-45
Pulverized, air floated, bagged	50-80	50-80
Kaolin, refined, bulk, f.o.b. works		
Coating clays	75-120	75-120
Filler clays	40-60	40-60
Pottery clays	30-80	30-80

f.o.b. Free on board.

TABLE 1. CANADA, IMPORTS AND EXPORTS OF CLAY, 1988P

		1988P Jan.-Sept.	
		(tonnes)	($000)
Imports			
2507.00	Kaolin and other kaolinitic clays whether or not calcinated		
	United States	297 581	43 375
	Other countries	228	123
	Total	297 809	43 498
2508.10	Bentonite		
	United States	162 603	8 163
	Greece	55 801	2 708
	Other countries	16 013	385
	Total	234 417	11 256
2508.20	Decolourizing earths and fullers earth		
	United States	4 844	567
	Total	4 844	567
2508.30	Fire-clay		
	United States	6 350	1 994
	United Kingdom	78	35
	Total	6 428	2 029
2508.40	Other clays (excluding expanded clays)		
	United States	145 824	20 021
	United Kingdom	510	162
	Italy	378	125
	Other countries	17 642	40
	Total	164 354	20 348
3802.90.10	Activated Clay		
	United States	2 436	2 231
	West Germany	68	42
	Total	2 504	2 273
Exports			
2507.00	Kaolin and other kaolinic clays whether or not calcined		
	West Germany	305	636
	United States	485	86
	Anguilla	4	3
	Total	794	725
2508.10	Bentonite		
	United States	854	261
	Other countries	38	4
	Total	892	265
2508.20	Decolourizing earths and fullers earths		
	West Germany	382	198
	Total	382	198

TABLE 1. (cont'd)

		1988P Jan.-Sept.	
		(tonnes)	($000)
2508.30	Fire-clay		
	United States	138	206
	East Germany	73	152
	Total	211	358
2508.40	Other clays (excluding expanded clays)		
	West Germany	795	1 646
	United States	756	319
	New Zealand	1	1
	Total	1 552	1 966

Source: Statistics Canada
P Preliminary.

TABLE 2. CANADA, VALUE OF PRODUCTION (SHIPMENTS) OF CLAYS AND CLAY PRODUCTS FROM DOMESTIC CLAY/SHALES SOURCES, 1986-88

	1986	1987	1988P
		($000)	
Production from domestic sources, by provinces			
Newfoundland	1 273	1 132	1 225
Nova Scotia	7 616	7 584	7 435
New Brunswick	3 026	2 935	2 975
Quebec	29 621	36 125	24 745
Ontario	109 998	131 568	122 203
Manitoba	3 470	2 958	2 278
Saskatchewan	5 700	5 633	5 530
Alberta	10 158	14 183	9 382
British Columbia	8 652	8 639	9 500
Total	179 514	210 756	185 273

P Preliminary.
Totals may not add due to rounding.

TABLE 3. CANADA, REPORTED CONSUMPTION[1] OF CLAYS, BY INDUSTRIES, 1984-87

	1984	1985	1986	1987P
	(tonnes)			
China Clay (kaolin)				
Pulp and paper products[2]	147 234	165 032	211 828	258 449
Ceramic products	9 527	9 468	9 866	10 205
Rubber products	7 225	7 850	8 569	10 584
Paint and varnish	6 065	6 347	5 575	6 517
Other products[3]	21 138	21 141	19 381	24 486
Total	191 189	209 838	255 219	310 241
Ball Clay				
Ceramic products misc.	16 506	15 090	18 374	18 331
Refractories	2 280	2 271	2 589	2 382
Other[4]	44 184	37 815	39 984	48 756
Total	62 970	55 176	60 947	69 469
Fire Clay				
Refractory brick, mixes	8 136	10 680	12 122	11 696
Foundries	8 514	8 247	9 073	5 991
Other[5]	27 383	17 906	41 403	58 099
Total	44 033	36 833	62 598	75 786

---

[1] Reported from EMR survey on the consumption of nonmetallic minerals by Canadian manufacturing plants. [2] Includes paper and paper products and paper pulp. [3] Includes refractory brick and mixes, fertilizers, glass fibre and glass fibre wool, chemicals, asphalt roofing products, wire and cable and other miscellaneous products. [4] Includes structural clay products, cements, paper and paper products, gypsum products and other miscellaneous products. [5] Includes structural clay products, ceramic products, primary steel, petroleum refining, rubber products, nonferrous smelting and refining and others.
P Preliminary.

TABLE 4. MAJOR CANADIAN MANUFACTURERS OF STRUCTURAL CLAY PRODUCTS AND REFRACTORIES, 1987, BY PROVINCE

Company	Plant Location	Products	Raw Material	Size[1] and Remarks
NEWFOUNDLAND				
Trinity Brick Products Limited	St. John's	building bricks	shale	(B)
NEW BRUNSWICK				
L.E. Shaw Limited	Chipman	facing brick, tiles, drainage and partition	shale	(E)
NOVA SCOTIA				
L.E. Shaw Limited	Lantz	brick, block and tile	common clay, ball clay	(E)

TABLE 4. (cont'd)

Company	Plant Location	Products	Raw Material	Size[1] and Remarks
QUEBEC				
Bricade Estrielle Inc.	Westbury	facing brick	common clay	(A)
Canada Brick Co., division of Jannock Limited	Laprairie	building brick and facing	shale	(G) bought from Domtar Inc. in 1985
Citadel Brick Ltd. division of Brampton Brick Limited	Beauport	building brick, drain tile and flue lining	shale	(C) sold to Brampton Brick Limited in 1986
Didier Refractories Corporation	Bécancour	refractory brick and shape, monolithics and mortar	alumina-silica, silica and basic	(E)
Dresser Canada, Inc. Canadian Refractories division	Grenville	refractory brick and shape, monolithics	alumina-silica and basic	(F)
Duquesne Refractories Limited	Dorval	refractory monolithics and mortar	alumina-silica and carbon	(A)
Montreal Terra Cotta Inc.	Deschaillons	building brick, tile and flue lining	shale, common clay	(B)
Quigley Canada Inc.	Lachine	refractory brick and shape, cements	fire clay, basic	(A)
St. Lawrence Brick Co. Limited	Laprairie	building brick	shale	(C)
ONTARIO				
A.P. Green Refractories (Canada) Ltd.				
Acton division	Acton	refractory brick and shape, monolithics, insulation	alumina-silica	(A)
Weston division	Weston		alumina-silica	(C)
Amos C. Martin Limited	Parkhill Wallenstein	drain tile	shale	(A)
Babcock & Wilcox Industries Ltd.	Burlington	refractory brick and shape monolithics, mineral wool	alumina-silica kaolin	(C)

TABLE 4. (cont'd)

Company	Plant Location	Products	Raw Material	Size[1] and Remarks
ONTARIO (cont'd)				
Bimac Canada Metallurgical Limited	Burlington	refractory brick and shape, mineral wool	alumina-silica	(B)
BMI Refractories Inc.	Smithville	refractory brick and shape, mortar	alumina-silica and basic	(A)
Brampton Brick Limited				
Brampton division	Brampton	building brick	shale	(C) new face brick plant under construction
Toronto division	Toronto	building brick	shale	(D)
Canada Brick Co.				(E)
Burlington division	Burlington	building brick	shale	new plant
Burlington division	Burlington	building brick	shale	
F.B. McFarren division	Streetsville	building brick	shale	
Mississauga division	Mississauga	building brick	shale	
Ottawa division	Ottawa	building brick	shale	
Streetsville division	Streetsville	building brick	shale	
Dochart Clay Products Co. Ltd.	Arnprior	tile	common clay	(B)
Dresden Tile Yard (1981) Limited	Dresden	building brick, tile and flue lining	shale	(A)
General Refractories Co. of Canada Ltd.	Smithville	refractory brick and shape, mortar	basic	(D)
George Coultis & Son Limited	Thedford	tile, drain tile	shale	(B)
Glassrock Products of Canada Ltd.	Hamilton	refractory brick and shape, monolithics	alumina-silica and fire-clay	(A)
Halton Ceramics Limited	Burlington	block and tile	common clay and shale	(A)
Hamilton Brick Limited	Hamilton	building brick	shale	(B)
National Refractories & Minerals Inc.	Oakville	refractory monolithics, mortar and insulation	alumina-silica and basic	(C)
National Sewer Pipe Limited	Oakville	flue lining and sewer pipe	shale and fire clay	(B)
	Oakville	face brick		new plant

TABLE 4. (cont'd)

Company	Plant Location	Products	Raw Material	Size[1] and Remarks
ONTARIO (cont'd)				
North American Refractories a division of General Chemical Canada Ltd.	Caledonia	refractory monolithics, mortar and insulation	alumina-silica	(B)
Plibrico (Canada) Limited	Burlington	refractory monolithics, mortar and mineral wool	alumina-silica zircon and basic	(E)
R & I - Ramtite Canada Limited C-E Refractories division	Welland	refractory monolithics and mortar; brick	alumina-silica	(C)
Riverside Refractories Canada Limited	Nanticoke	refractory shapes and mortars	alumina-silica	(A) new plant
MANITOBA				
I.XL Industries Ltd. Red River Brick and Tile division	Lockport	brick and tile	common clay	(E)
SASKATCHEWAN				
A.P. Green Refractories (Canada) Ltd.	Claybank	brick and shape	alumina-silica	(A)
I.XL Industries Ltd. Western Clay Products division	Regina	facing brick, flue lining and sewerpipe	stoneware clay	(A)
Thunderbrick Limited Estevan Brick division	Estevan	building brick	ball clay	(C)
ALBERTA				
I.XL Industries Ltd.				
Medicine Hat Brick and Tile division	Medicine Hat	brick, block, tile	common clay	(D)
Medicine Hat Sewer Pipe division	Medicine Hat	sewer pipe and flue lining	common clay	(A)
Northwest Brick and Tile division	Edmonton	building brick	common clay	(B)
Redcliff Pressed Brick division	Redcliff	facing brick and fire brick	common clay	(B)
BRITISH COLUMBIA				
Clayburn Refractories Ltd.	Abbotsford	refractory brick, mortar and monolithics	alumina-silica	(D)
Fairey & Company, Limited	Surrey	refractory brick and shape, monolithics, mortar	alumina-silica	(A)
Sumas Clay Products Ltd.	Sumas	brick, drain tile and flue lining	common clay	(C)

---

[1] Size keys: (A) up to 25 employees; (B) 25-49; (C) 50-99; (D) 100-199; (E) 200-499; (F) 500-999; (G) over 1000 employees.

TABLE 5. TYPICAL BODY COMPOSITIONS OF WHITE CERAMICS, (% OF TOTAL SOLIDS)

Whiteware type	Kaolin	Ball clay	Flux[1]	Quartz[2]	Others
Earthenware	25	25	15	35	-
Porcelain	60	10	15	15	-
Bone china	25	-	25	-	50 bone ash
Vitreous-china sanitaryware	20-30	20-30	15-25	30-40	0-3 talc
Electrical porcelain	20	30	30	20	-
Wall tiles	20	30	-	30-25	10-12 limestone

Source: British Geological Survey (BGS), Mineral Dossier 26.

[1] Usually K-feldspar, nepheline-syenite or china stone. [2] Silica sand and calcined sand or flint.

- Nil.

TABLE 6. KAOLIN: WORLD PRODUCTION, 1984-86, MAJOR COUNTRIES

	1984	1985	1986P
	(000 tonnes)		
United States	7 220	7 070	7 760
United Kingdom	2 990	3 150	3 090[e]
U.S.S.R.[e]	2 810	2 900	3 990
Colombia	940	1 040	1 560
Spain	320	320	370
South Korea	720	660	850
Czechoslovakia	670	650[e]	650[e]
India[1,2]	620	700	830
Brazil[2]	490	530	530
West Germany	360	410	510
Romania	410	410	410
France	310	1 500[3]	1 350[3]
Others	2 780	2 990	1 830
Total	20 640	22 330	23 730

Source: U.S. Bureau of Mines, 1987, clays, S. Ampian.

[1] Crude, saleable kaolin. [2] Processed.

[3] Includes kaolinitic clay.

P Preliminary; e Estimated.

Coal

J.A. AYLSWORTH

The Canadian coal industry built on the momentum of 1987 and set new production records in 1988. Preliminary figures suggest that based on strong international demand for coking coal and additional domestic demand for thermal coal, production grew to a record 70 Mt and exports reached an all time high of nearly 32 Mt. Domestic coal consumption of all types also reached record levels contributing to both increased production and imports. Other positive developments included the opening of two new coal mines, announcements of plans to build new coal-fired power plants and a joint government/industry commitment to help fund new research, development and demonstration initiatives to enhance market opportunities for low-sulphur western Canadian coal.

In spite of these positive developments, however, the calendar year ended with both United States and Australian exporters concluding 1989/1990 fiscal year contracts with the Japanese steel industry at prices which are only likely to prolong and aggravate the financial difficulties of exporters strained by several years of falling prices. Outside of giving up some market share Canadian exporters had little recourse but to accept the Australian benchmark price.

A report on British Columbia's coal producers prepared for the Coal Association of Canada documented the financial situation of Canada's export coal industry. It noted that the triple burden of low coal prices, unfavourable exchange rates, and taxes and royalties combined to limit returns to British Columbia's exporters on common equity to an average of only 3.5% and returns on total capital employed to only 1.3%. Later in 1988, the New South Wales Coal Association in Australia released its annual financial report for 1987-88, confirming its largest ever deficit. The closure of a number of Australian mines, along with reported financial difficulties and low profits of other major exporters, including Colombia and South Africa, demonstrated that many private enterprise coal producers cannot make acceptable returns at today's export prices.

Attention was also focused on the domestic thermal coal sector by the May 1988 endorsement by the Deputy Prime Minister/Premiers' Action Committee on Western Canadian Low-Sulphur Coal to Ontario, of recommendations for federal participation in the development of technologies to enhance the competitiveness of western coal. Several research, development and demonstration (RD&D) initiatives will be jointly funded by the federal and provincial governments and the private sector. Fourteen projects, estimated to cost $81 million, were tentatively identified as having the potential to enhance the competitiveness of western low-sulphur coal and thus to facilitate users' actions to reduce acid gas emissions.

DOMESTIC CONSUMPTION AND MARKETS

Overall Canadian coal consumption grew by an estimated 10% in 1988 to 55 Mt, primarily due to increased consumption of thermal coal for the generation of electricity. Consumption by the steel industry and other users (industrial/commercial users) is predicted to be relatively unchanged from last year at just over 6 and 2 Mt respectively, while coal consumption for electricity generation grew to nearly 47 Mt.

All six provinces using coal to generate electricity recorded increases in consumption in 1988 in response to increased load growth requirements and, in some cases, lower than expected electricity output from other system options. In most instances the additional coal came from indigenous mines, although some new supply sources also emerged during the year.

Thermal coal demand increased by 15% in Nova Scotia in 1988, and will continue to increase in the 1990s as a result of commitments for two new 150 MW coal fired

---

J.A. Aylsworth is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 992-5086.

power units. Work on one unit, at the Trenton station, began in 1987 and is scheduled to be completed in the latter half of 1991. Work on the new unit at Point Aconi, near Sydney, is scheduled to begin in 1989. This unit will use state-of-the-art circulating fluidized bed technology, which employs limestone to capture most of the sulphur in the coal during combustion. It will utilize 400 000 t/y of coal and 150 000 t/y of limestone. The coal for these and subsequent stations will come from Nova Scotian mines.

Thermal coal demand grew in New Brunswick by about 30% during 1988 in response to increased demand for electricity. While more than 85% of this coal came from provincial mines, some of the additional coal used in 1988 came from Nova Scotia, United States and Colombia.

Ontario Hydro also continued to diversify its coal supply options during 1988, consuming about 4.7 Mt of western Canadian coal, and about 8.4 Mt of United States coal. For the first time, Ontario Hydro imported small quantities of western United States sub-bituminous coals on a trial basis to evaluate their economic and technical suitability.

Consumption of lignite, sub-bituminous and bituminous coals in the prairie provinces grew by 3 Mt or 10% in response to increased load growths and lower water levels. Alberta and Saskatchewan consume locally produced coal while Manitoba obtains lignite coal from Saskatchewan.

Construction began in 1988 on the first of two 300 MW coal units for the new Shand Power Station in southeastern Saskatchewan. A new 2 Mt coal mine will be developed to produce the lignite coal required to fuel this unit which is scheduled to come on stream in 1992. A second 300 MW unit is planned for 1995.

Coal demand in Alberta will grow by an additional 1.5 Mt/y as a result of the 400 MW Genesee Power Station scheduled to begin operation in October 1989. Stockpiling of coal at the new Genesee coal mine south of Edmonton began in December, 1988. The $100 million mine will eventually produce 3 Mt/y when the second 400 MW unit is operational later in the 1990s.

While coal consumption in the steel and other industry sectors remained relatively unchanged in 1988, considerable attention was focused on a potential new industrial market for coal. Early in the year the first industrial boiler in North America to use coal-water fuel (CWF) commercially was commissioned in Hantsport, Nova Scotia. CWF is a mixture of 70% finely ground coal and 30% water with small amounts of chemicals to stabilize the coal suspension and control its viscosity. The mixture can be transported in pipelines and stored in tanks. It offers significant environmental benefits, since sulphur minerals are removed during the fine grinding.

Towards the end of 1988, technical and economic problems resulted in the temporary suspension of the use of CWF at the Hantsport facility. The technical problems are expected to be resolved in early 1989. When operating at full capacity, the Hantsport facility will consume 18 000 t of CWF, which would replace 65 000 barrels of oil. CWF could offer potential new markets for Canadian coal in both the industrial and commercial sectors.

TRADE

Canada remains unique among coal trading nations being both a major coal exporter and importer. Its ranking as the fifth largest exporter was solidified during 1988 as shipments grew by nearly 20% to approach 32 Mt. This increase reflects the accelerated pace of steel production in Japan, South Korea, Brazil, Europe and elsewhere.

Japan has traditionally been Canada's largest coal customer, taking an average of nearly two-thirds of all exports. This proportional offtake remained the same during calendar year 1988 as crude steel production in Japan rose to a four year record of 105 Mt, in response to buoyant domestic and export markets. Japanese imports of Canadian coking coals increased by approximately 25% during 1988, while overall coking coal imports increased by nearly 15%. Japan also remained Canada's major thermal coal customer during the year.

South Korea and Brazil remained Canada's second and third largest markets, with the former market increasing its imports of both coking and thermal coal in 1988 and the latter its imports of coking coal. Exports of coking coals to the United States and European markets also increased during 1988 due to the strength of their steel sectors.

The increased international demand for coking coal brought into focus some weak links in coal supply chains that were not apparent in the oversupplied markets of the 1980s. These weaknesses may presage supply problems for the future. Examples include the reduction in production capacity brought about by the closure of a number of Australian coal mines in 1988. Australian exports were also interrupted in 1988 by labour disputes related to a major government and industry restructuring program. Chinese exports were constrained by domestic requirements and production and deliverability problems. South African exports were limited in some markets by trade sanctions and constrained by domestic problems, including large freight rate increases and major exchange rate fluctuations. The need to restructure its industry and growing domestic demands signalled potential limitations to growth in Polish coal exports.

These and other current supply-side problems along with a buoyant coking and thermal coal demand in 1988 created the most balanced international market in several years. Exporters who had suffered through several years of declining prices and subsequent unacceptable financial returns hoped that this would translate into meaningful price increases. A 20% price increase won from Japanese thermal customers by some Australian thermal coal exporters in the fall of 1988 was seen by some as a hopeful omen for the coking coal negotiations which traditionally start in the final months of each calendar year.

Events soon proved that this initial optimism was unfounded. Contract negotiations for fiscal year 1989-1990 coking coal exports to Japan were concluded quickly first with leading United States and then prominant Australian exporters. The settlement with the Australians was for an average US$3.50 (about 8%) increase for hard coking coals and a $5.50 (about 15%) increase for semi-soft coking coals. This brought the 1989 weighted average prices to a little over US$49 and US$42 respectively.

Canadian coking coal exporters had no alternative but to accept the precedent setting agreements of the Australians in order to maintain their market share. However, exporters in Canada and Australia (and most other private sector exporters) required larger price improvements to ensure long term production flexibility and acceptable financial returns. In the absence of adequate price increases, coal importers face the risk of insufficient new mine investments in stable coal exporting countries. In the longer term, this could result in increased dependence on marginal and less reliable coal exporters.

CHALLENGES OF THE 1990s

Coal producers and users in the 1990s will face the economic and supply and demand problems carried over from the 1980s in addition to emerging environmental challenges of the 1990s. It has been clear for some time that the use of thermal coal for the generation of electricity would be the major growth sector in international coal trade in the 1990s. The Asia-Pacific region and western Europe will experience the largest increase. In many of these countries, and in most coal consuming nations, regulations on acid gas emissions are being tightened. This has accentuated the growth in demand for low-sulphur coals and given impetus to the development of more environmentally benign applications for burning a wide range of coals.

International attention is also beginning to focus on the causes and consequences of the "greenhouse effect" and the depletion of the ozone layer. The combustion of all fossil fuels, including gasoline, fuel oil, natural gas and coal, together with the emissions from forest clearing and burning and the release of commercial and industrial gases (such as chlorofluor carbons and nitrous oxide), combine to produce man-made radiative gases that are believed to contribute to the "greenhouse effect". A major challenge for all fossil fuel producers and consumers in the 1990s and beyond will be to involve themselves in the resolution of these environmental concerns.

OUTLOOK

There is every indication that Canadian coal production will increase in response to growing domestic and international demand in the future. Domestic demand growth will be based, in the short to medium term time horizon, on increases in electrical energy production in Alberta, Saskatchewan, Manitoba, Ontario, New Brunswick and Nova Scotia. The major increases will occur in the two western and eastern provinces, which are adding new coal fired generating capacity. There may also be some limited near term opportunities to increase domestic coal use in the industrial sector through such new technologies as coal water fuels, although this market potential is relatively small.

Production of Canadian coal for export is also forecast to increase in 1989 and beyond, but not at rates equal to the growth of the domestic market. International demand for coking coal is predicted to stabilize at near the current 160 Mt/y level while thermal coal trade for electrical and industrial markets is forecast to eventually double early in the 21st century to more than 300 Mt/y. About 80% of Canadian coal exports have traditionally been directed towards coking coal markets. While this division is likely to change slowly towards thermal coal in the future, the majority of near term Canadian exports will continue to be coking coal.

Overall Canadian coal production is forecast to grow by about 5%, to about 73 Mt in 1989 and reach about 75 Mt in 1990 based primarily on increased domestic demand for thermal coals. Exports are forecast to grow by about 2% to about 33 Mt in 1989 partly due to new exports from the new Quinsam coal mine which began production on Vancouver Island in 1988.

Future prices for internationally traded coals will be determined by the balance between demand and supply and other factors, including the price of oil. Coal quality differences are also likely to more strongly influence prices in the future. Exporting producers will have to contend with these uncertainties and with concerns over long term viability if coal prices do not increase to levels sufficient to provide satisfactory returns.

Other factors that will impact on international coal trade include currency fluctuations, the level of subsidized coal production in Europe and elsewhere, and the development of new production/marketing/consumption arrangements such as those being considered through the Pacific Coal Flow Concept.

Unlike many other mineral and energy commodities, the coal industry has not been able to capitalize on the recent buoyant markets to improve its financial returns. This will be the priority for many exporters in Canada and elsewhere in the near term. Most other concerns will be secondary to this overriding issue, and its successful resolution is of equal importance to coal sellers and, in the mid- to longer term, to coal purchasers.

TABLE 1. SUMMARY OF COAL SUPPLY BY TYPE AND VALUES, 1984-88

	1984		1985		1986		1987		1988P	
	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)
DOMESTIC[1]										
Bituminous										
Nova Scotia	3 094	162 000	2 800	158 000	2 695	155 000	2 925	179 000	3 425	212 000
New Brunswick	564	30 000	560	30 000	490	27 000	533	32 800	545	33 000
Alberta	7 630	337 000	7 841	331 000	6 994	262 000	7 202	247 000	9 650	337 000
British Columbia	20 775	1 020 000	22 994	1 106 000	20 359	881 000	21 990	948 000	24 235	1 090 000
Total	32 062	1 549 000	34 195	1 625 000	30 538	1 325 000	32 650	1 406 000	37 855	1 672 000
Sub-bituminous										
Alberta	15 422	126 000	16 871	146 000	18 225	163 000	18 537	166 000	19 620	177 000
Lignite										
Saskatchewan	9 918	131 000	9 672	135 000	8 281	122 000	10 020	129 000	12 025	144 000
Total	57 402	1 806 000	60 738	1 906 000	57 044	1 610 000	61 207	1 701 000	69 500	1 993 000
IMPORTED[2]										
Bituminous and anthracite briquettes	18 352	1 366 000	14 867	1 124 000	13 125	999 000	14 719	899 000	17 500	1 015 000
Total	75 754	3 172 000	75 605	3 030 000	70 169	2 609 000	75 926	2 600 000	87 000	3 008 000

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] F.o.b. mines. [2] Value at United States ports of exit.

P Preliminary figures or estimates.

TABLE 2. PRODUCER'S DISPOSITION OF CANADIAN COAL[1], 1987

Destination	Deliveries From Nova Scotia	New Brunswick	Saskatchewan	Alberta	British Columbia	Canada
			(000 tonnes)			
Newfoundland	1	-	-	-	-	1
Prince Edward Island	5	-	-	-	-	1
Nova Scotia	2 375	-	-	-	-	2 375
New Brunswick	-	533	-	-	-	533
Quebec	59	-	-	-	-	59
Ontario	-	-	1 524	1 649	1 064	4 237
Manitoba	-	-	638	1	39	678
Saskatchewan	-	-	7 857	1	42	7 900
Alberta	-	-	-	18 896	2	7 900
British Columbia	-	-	-	23	178	201
Total Canada	2 436	533	10 019	20 570	1 325	34 883
Japan	-	-	-	4 238	12 827	17 065
Others	490	-	-	883	8 302	9 675
Total shipments	2 926	533	10 019	25 691	22 454	61 623

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Saleable coal (raw coal, clean coal and middling sales).
- Nil.

TABLE 3. SUMMARY OF COAL SUPPLY-DEMAND, 1977-88

Year	Canada Production Bituminous	Sub-Bituminous	Lignite	Total	Imports Anthracite	Bituminous	Total Available	Domestic Consumption	Exports
				(million tonnes)					
1977	15.3	7.9	5.5	28.7	0.4	15.0	44.1	30.8	12.4
1978	17.1	8.3	5.1	30.5	0.3	13.8	44.6	31.7	14.0
1979	18.4	9.6	5.0	33.0	0.2	17.3	50.5	34.8	13.7
1980	20.2	10.5	6.0	36.7	0.3	15.5	52.5	37.3	15.3
1981	21.7	11.6	6.8	40.1	0.4	14.4	54.9	38.4	15.7
1982	22.3	13.0	9.5	42.8	0.3	15.5	58.6	41.5	16.0
1983	22.5	14.5	7.8	44.8	0.3	14.4	59.5	43.6	17.0
1984	32.1	15.4	9.9	57.4	0.2	18.1	75.7	48.6	25.1
1985	34.2	16.8	9.7	60.7	0.3	14.6	75.6	48.7	27.4
1986	30.5	18.2	8.3	57.0	0.4	12.7	70.1	44.6	25.9
1987	32.7	18.5	10.0	61.2	0.4	14.3	75.9	50.1	26.7
1988P	37.9	19.6	12.0	69.5	0.4	17.1	87.0	55.0	31.5

Sources: Statistics Canada; Energy, Mines and Resources Canada.
P Preliminary.

TABLE 4. COAL USED BY THERMAL POWER STATIONS IN CANADA, BY PROVINCES, 1969-88

	Nova Scotia	New Brunswick	Ontario	Manitoba	Saskat-chewan	Alberta	Total Canada
				(000 tonnes)			
1969	676	150	6 424	51	1 123	2 378	10 802
1970	548	113	7 696	503	1 969	2 951	13 780
1971	689	271	8 560	446	1 996	3 653	15 615
1972	663	281	7 599	410	2 145	4 113	15 211
1973	585	193	6 615	386	2 806	4 474	15 059
1974	606	292	6 721	132	2 902	4 771	15 424
1975	571	248	6 834	323	3 251	5 345	16 572
1976	730	207	7 612	979	3 521	5 996	19 045
1977	572	198	8 795	1 113	4 304	7 461	22 443
1978	771	151	9 097	341	4 585	8 029	22 914
1979	644	198	9 901	73	4 956	9 181	24 956
1980	1 052	315	10 779	240	4 972	10 424	27 782
1981	1 126	515	11 460	332	4 935	11 445	29 813
1982	1 300	548	12 484	184	5 897	13 242	33 656
1983	1 400	564	13 025	109	6 625	14 492	36 216
1984	1 974	610	13 413	163	7 925	16 123	40 208
1985	2 235	521	10 985	253	8 290	18 112	40 396
1986	2 137	469	9 172	111	6 786	17 719	36 394
1987	2 077	526	12 016	457	7 672	19 077	41 825
1988P	2 400	700	13 300	780	8 600	20 800	46 550

Sources: Statistics Canada; Energy, Mines and Resources Canada.
P Preliminary.

TABLE 5. SUMMARY OF COAL DEMAND, 1983-88

	1983	1984	1985	1986	1987	1988P
			(000 tonnes)			
DEMAND						
Thermal Electric						
Canadian	26 748	29 935	32 563	30 035	33 932	38 100
Imported	9 468	10 273	7 833	6 359	7 893	8 450
Total	36 216	40 208	40 396	36 394	41 825	46 550
Metallurgical						
Canadian	102	-	52	243	290	20
Imported	5 481	6 542	6 210	5 891	6 019	6 280
Total	5 583	6 542	6 262	6 134	6 309	6 300
General Industry						
Canadian	847	813	582	655	594	650
Imported	1 003	1 136	1 416	1 375	1 416	1 500
Total	1 850	1 949	1 998	2 030	2 010	2 150
Exports						
Canadian	17 011	25 138	27 378	25 943	26 740	31 500
Total						
Canadian	44 708	55 886	60 575	56 876	61 556	70 270
Imported	15 952	17 951	15 459	13 625	15 328	16 330
Grand Total	60 660	73 837	76 034	70 501	76 884	86 600

Sources: Statistics Canada; Energy, Mines and Resources Canada.
P Preliminary; - Nil.

TABLE 6. EXPORTS OF CANADIAN COAL BY DESTINATION

	Jan.-Oct. 1988	Jan.-Oct. 1987
Belgium	47	-
Brazil	1 440	990
Chile	156	153
Denmark	235	301
Egypt	87	-
France	406	436
Hong Kong	-	313
Italy	25	21
Japan	17 101	14 162
Netherlands	344	223
Mexico	55	-
Pakistan	126	150
Portugal	217	149
South Korea	4 149	3 080
Sweden	92	318
Taiwan	956	565
Turkey	51	53
United Kingdom	405	279
United States	862	607
West Germany	109	211
Total	26 863	22 011

Source: Statistics Canada and Energy, Mines and Resources Canada joint survey, Coal.
- Nil.

TABLE 7. CANADA, COAL PRODUCTION, IMPORTS, EXPORTS AND CONSUMPTION, 1983-88

	Production	Imports	Exports	Domestic Consumption
	(000 tonnes)			
1983	44 780	14 667	17 011	43 649
1984	57 402	18 352	25 138	48 699
1985	60 738	14 867	27 378	48 656
1986	57 044	13 125	25 943	44 558
1987	61 200	14 719	26 740	50 144
1988P	69 500	17 500	31 500	55 000

Sources: Statistics Canada; Energy, Mines and Resources Canada.
P Preliminary figures or estimates.

TABLE 8. CANADA, COKE PRODUCTION AND TRADE, 1977-87

	Production		Imports		Exports	
	Coal	Petroleum	Coal	Petroleum	Coal	Petroleum
	(tonnes)					
1977	4 845 066	921 363	382 827	986 678	198 727	157 191
1978	4 967 664	1 014 076	553 349	973 985	217 595	134 762
1979	5 775 141	1 105 433	520 534	980 657	228 601	125 416
1980	5 249 744	1 156 444	626 923	908 322	319 554	150 200
1981	4 659 007	1 098 397	653 645	935 929	190 879	200 149
1982	3 999 117	1 083 129	453 915	650 810	129 793	104 897
1983	4 120 002	986 730	576 649	759 954	45 606	65 323
1984	4 900 478	1 072 983	660 257	886 734	116 226	55 300
1985	4 683 770	1 099 808	369 224	866 530	46 882	45 968
1986	4 552 532	765 867	432 730	941 314	108 787	46 554
1987	4 636 629	1 039 556	599 015	964 949	151 974	53 118

Copper

W. McCUTCHEON

Canadian copper producers benefited from record high copper prices in 1988, recovering an estimated 725 000 t of copper from Canadian mines. Production is forecast to rise to 800 000 t in 1989, assuming no significant disruptions. Copper recovered at Canadian smelters from domestic concentrate plus payable copper in concentrates and mattes exported totalled 776 000 t in 1987 and is estimated at 713 000 t in 1988. Refined production in 1988 is estimated at 520 000 t and is forecast at 530 000 t for 1989.

Western world copper demand increased beyond expectations in 1988 but supply remained tight due to various production problems. In 1988 the combined inventories on the London Metals Exchange (LME) and the Commodities Exchange, Inc. (COMEX) increased from 69 712 t to 77 929 t. Settlement prices reached historic highs in 1988, and averaged US$1.18/lb. on the LME and US$1.15 on COMEX.

Details of tonnage mined and concentrates produced in 1987 at Canadian nonferrous and precious metals mills can be found in the table "Principal Canadian Nonferrous and Precious Metal Mine Production..." which follows the final commodity chapter of this yearbook. Highlights for 1988 are also included in the table.

In addition to the mines covered in this copper chapter, copper is produced at other mines as a by-product. The reader should refer to the zinc chapter for information about events at Brunswick, Isle Dieu, Winston Lake and Faro mines and the gold chapter for information about the gold-copper producers in the Chibougamau area.

SUPPLY: CANADIAN DEVELOPMENTS

In **Newfoundland**, Noranda Inc. and BP Resources Canada Limited continued exploration of their Tally Pond-Duck Pond joint venture. Drilling has shown reserves of 4 Mt containing 3.5% Cu along with other metals. It could prove an important feed source for Noranda's Murdochville copper smelter. Further exploration is planned for 1989.

In **Quebec**, Minnova Inc.'s Ansil mine will commence production in the first quarter of 1989. It will produce about 30 000 t/y of copper in concentrates. Reserves are 1.52 Mt grading 7.2% Cu. Having discovered additional reserves, Audrey Resources Inc. decided to spend $17 million to build a 1 000 t/d mill at its Mobrun mine, near Ansil. Noranda committed $20 million to reopen its Murdochville mine previously closed after a fire in April 1987. Beginning in the first quarter of 1989 Noranda will mine the E-32 orebody (2.8 Mt at 2.77% Cu) at 3 000 t/d, five days per week. At the Horne smelter, work began on the $125 million acid plant that should be operational by the end of 1989. Noranda will close its reverberatory furnace in early 1989 but will have the option of restarting it when the acid plant is completed. At Noranda's Montreal East copper refinery, the company initiated a tankhouse modernization program.

In **Ontario**, Falconbridge Limited decided to spend $32.6 million to further define four mineralized zones in the Lindsley deposit in the Sudbury basin. The company will sink a 5 m diameter shaft 1400 m deep and drill from the 1300 m level. One previous exploration hole returned 4.4% Cu and 2.3% Ni over 78 m. At its Strathcona mine, Falconbridge continued definition drilling of a 4 Mt copper orebody. The company expects to start production from this orebody in late 1989.

INCO Limited announced a program to rationalize nickel-copper milling operations and control sulphur emissions in Sudbury. The company will close its Frood-Stobie mill after completing a $69 million modification of the Clarabelle mill. INCO continued development of the Lower Coleman and Crean Hill mines as all-electric mines for 1989 and 1990 startups, respectively. Electrical equipment reduces operating costs by lowering ventilation requirements and making automation easier.

W. McCutcheon is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 992-4403.

By the end of the third quarter, Noranda owned almost 19.6% of Falconbridge's stock. Noranda announced its intent at the end of November to purchase another 10% of Falconbridge shares, but with no obligation to do so.

In **Manitoba,** Hudson Bay Mining and Smelting Co., Limited (HBMS) proposed a $130 million program to reduce sulphur dioxide emissions and modernize its copper and zinc smelters. HBMS asked the federal and provincial governments for loans to supplement its capital input. The program would include replacing the existing roasters and reverberatory furnace in the copper smelter with a Noranda reactor. At HBMS's Ruttan mine, a labour dispute closed the operation from June 1 to September 8. Ruttan supplied 39% of the feed to the HBMS copper smelter in 1987. During the strike, HBMS operated the smelter with feed from the other HBMS mines, supplemented with purchased concentrates. At the Trout Lake mine, shaft sinking was completed to 560 m. Additional development and ramping through 1989 will bring the lower levels of the mine into production by 1990 and reduce operating costs.

In **Saskatchewan,** the newly discovered Hanson Lake deposit located 65 km west of Flin Flon was described as a "Trout Lake" type of deposit. Trout Lake reserves at the end of 1987 were 5 Mt of ore grading 1.89% Cu, 5.7% Zn, with gold and silver. If significant tonnage were proven at Hanson Lake, it would be an important contribution to the reserve base of the region.

In **British Columbia,** Afton Operating Corporation (owned 73% by Teck Corporation) intends to spend $12 million to bring the Ajax copper-gold property into production. Once permitting is completed, the company plans to commence mining the 25 Mt deposit grading 0.4% Cu at the rate of 10 000 t/d, in the spring of 1989.

At Noranda's Bell mine, the company spent $13 million over 2 years on exploration. After delineating 9 Mt of additional ore, Noranda extended the mine life from 1990 to the end of 1992. At Brenda Mines Ltd., exploration uncovered additional ore. After reaching agreement with British Columbia Hydro and Power Authority (B.C. Hydro) to relate hydro charges to copper prices, the company extended the mine life by a year. The 30 000 t/d Brenda mine will close in mid-1990.

A labour dispute shut Gibralter Mines Limited's mine and mill from May 11 to November 28. During the strike, the 4 500 t/y solvent extraction/electrowinning (SXEW) plant continued copper recovery from low grade dumps. In 1987, the mine produced 33 500 t of copper in concentrates and 3 900 t of copper cathodes.

In January 1988, Highmont Mining Company and Highland Valley Copper partners agreed to include the Highmont operations in HVC. The Highmont mill will be moved to the existing Lornex mill site and reassembled as an addition by May 1989 at a cost of $70 million. When HVC closes the Bethlehem mill in mid-1989, it will have a milling capacity of 131 000 t/d, the third highest milling capacity among world copper mines.

Effective May 31, Cassiar Mining Corporation purchased Newmont Mining Corporation's Similkameen operation for $10 million. Cassiar obtained a new contract with the workers and rescheduled loan repayments to B.C. Hydro. While Newmont had planned to close the mine in two years, Cassiar will continue operations for a minimum of seven years. The new company, Similco Mines Ltd., increased production from 20 400 t/d to 22 700 t/d. On Vancouver Island, Westmin Resources Limited completed a mill expansion to 4 000 t/d in mid-1988.

Located in the extreme northwest corner of British Columbia, Geddes Resources Limited's Windy Craggy property is the largest potential copper deposit being explored in Canada. Drilling in 1988 indicated reserves exceeding 90 Mt with a grade between 2% and 3.5% Cu with gold and silver. Continuity has been established for 600 m of 1800 m of known mineralization. Work will continue in 1989. Windy Craggy is located 80 km from a paved highway and 240 km from a deepwater port at Haynes, Alaska.

While Canadian output should increase by 10% to 800 000 t of recovered copper in 1988, there is concern about maintaining future production. Past years of low copper prices curtailed exploration expenditures. Hence between 1982 and 1987, Canadian reserves of copper, contained in proven and probable mineable ore at mines in production and in committed projects, fell from 17 Mt to 13 Mt.

SUPPLY: WORLD DEVELOPMENTS

In 1988 the industry continued to benefit from the strong prices that reached historic highs. A number of corporate changes were either completed or in the negotiations stage.

In the **United States,** production increased 14% to an estimated 1.45 Mt (including SXEW copper) after having risen almost 11% in 1987. ASARCO Incorporated planned to increase its mine production to 195 000 t, 10% above 1987 output. It purchased the Helvitica copper-molybdenum property, about 25 km from its Mission Complex. ASARCO expects Mission to reach a production rate of 78 000 t/y in 1989.

BP America Inc. completed modernization of its Bingham Canyon operations in Utah. The US$400 million program included an in-pit crusher, a conveyor and a new concentrator. Productivity in the modernized section of the facilities increased from 28 t of contained copper per person-year in 1980 to 100 t/person-year. This makes Bingham Canyon one of the lower cost operations in the world. With high copper prices, the company continued mining lower grade material and using old facilities to produce more copper than previously scheduled.

At year-end it was announced that the majority of mineral holdings of The British Petroleum Company p.l.c. (BP Minerals International Ltd.'s mineral holdings) would be sold to RTZ Corporation PLC. Included in the sale are the Bingham Canyon facilities in Utah. Other properties in the sale include a 49% share in the Olympic Dam uranium-copper operation which started up in Australia in 1988. This sale, which excludes mineral holdings of BP Canada Inc. such as the Selbaie property, would give RTZ about 6.5% of the world copper supply, assuming that Western Mining Corporation Limited does not exercise its first right of refusal to purchase the 49% interest in Olympic Dam.

Cyprus Minerals Company aggressively increased its copper holdings to make it the second ranked copper producer in the United States, after Phelps Dodge Corporation. Cyprus acquired Inspiration Consolidated Copper Company's Miami smelter and SXEW facilities in July, leased the Twin Buttes mine for 15 years, purchased the Tonopah molybdenum-copper mine in July and bought the Pinos Altos operation in New Mexico from Boliden AB. (In 1987 Cyprus acquired the Lakeshore mine from Noranda). The company's copper operations were reorganized into a subsidiary operation, Cyprus Copper Company, expected to produce 180 000 t of copper in 1988 and about 240 000 t in 1989.

On July 7 Magma Copper Company started up its new 900 000 t/y capacity flash furnace. The last reverberatory furnace at the operation was closed down August 12, eleven weeks ahead of a regulatory deadline. The new furnace is the central part of Magma's US$283 million modernization program that encompasses an acid plant, mill modernization, and development of the Kalamazoo orebody. Magma offered US$200 million in copper-indexed subordinated notes, linking interest rates to copper. This is the first major commodity-linked debt in the United States since 1986.

Mitsubishi Metal Corporation announced its intention to build a 150 000 t/y copper smelter in the United States. Mitsubishi expects to choose the location for the smelter by early 1989. The company hopes that the smelter will begin production in late 1991. Mitsubishi owns a portion of the Escondida mine in Chile and will start taking delivery of concentrates in 1991.

Phelps Dodge Corporation produced 425 400 t from its share of domestic operations in 1987. At the Chino operation, in which PD owns a 2/3 share, a 40 000 t/y SXEW installation was completed. PD also undertook a study of the Cochise project in Arizona near Bisbee. The 135 Mt Cochise orebody could yield about 45 000 t/y of SXEW copper starting in the early 1990s. A decision is expected in early 1989.

In **Mexico,** Fomento Industrial de Norte de Mexico S.A. (owned 34% by ASARCO) and a labour union purchased Mexicana de Cobre S.A. from the Mexican government for US$1360 million in November. Five hundred million dollars U.S. was in the form of assumed liabilities and the remainder in equity and debt reduction.

In **Chile** copper production in the first nine months of the year totalled 1.038 Mt, slightly higher than the 1.036 Mt produced in the same period of 1987. Through the year, troubles plagued the world's largest producer, state-owned Corporacion Nacional del Cobre de Chile (Codelco-Chile). The company reduced its 1988 production target from 1.168 Mt at the start of 1988 finally to an estimated 1.09 Mt in December, the same as in 1987. Production for the company is scheduled to rise to 1.242 Mt in 1989, up 14% from 1987.

At Codelco-Chile's El Teniente mine, the world's largest underground copper mine, production was reduced in late 1987 due to a rock burst. It produced only 357 000 t of contained copper in 1988 compared to 390 000 t in 1987. It is scheduled to produce 344 000 t in 1989. At the El Salvador mine, production was reduced to comply with a court order forbidding tailings discharge into Chanral Bay. The company must build a new tailings dam within a year. Production declined to 86 000 t in 1988 from 105 000 t in 1987, also due to past changes introduced to reduce costs when prices were low.

At Chuquicamata, the new flash smelter started production in the third quarter. It replaces some of the existing reverberatory smelter capacity while raising overall capacity from 1.1 Mt/y of concentrates to 1.5 Mt/y. But when the US$112 million mill expansion from 102 000 t/d of ore to 153 000 t/d is completed in mid-1989, Chuquicamata will still be able to produce more concentrates than the smelter can handle. Increased acid production from the new smelter and acid plant will make copper recovery from the 600 Mt of 0.3% Cu material in dumps more economic. The refinery capacity was increased from 475 000 t/y to 750 000 t/y by year end. Chuquicamata produced 518 000 t of copper in 1988; in 1989 and 1990 production is scheduled to rise to 662 000 t and 750 000 t, respectively. By 1990, the grade will fall to an average of 1.4% (from 2.5% in 1975 and 1.6% in 1988) and further decline to 1.0% by the end of the century.

The Australian, British and Japanese partners in the Escondida project arranged financing to develop the US$1100 million open pit mine, mill and port project in northern Chile. Construction began in 1988 with start up targetted for 1991. While Canada's Export Development Corporation provided US$25 million in export financing for the project, the bulk of the financing ($537 million of the US$680 million lent) came in the form of import financing from Federal Republic of Germany, Japan and Finland. These countries provided financing assistance to obtain long term (1991-2002) supplies of copper concentrates. The Import-Export Bank of Japan and other Japanese institutions agreed to supply US$350 million, and 380 000 t/y of concentrates will go to seven Japanese firms; Kreditanstalt Fuer Wiederaufbau (KFW) of the Federal Republic of Germany agreed to provide US$140 million, and 150 000 t/y of concentrates will go to Norddeutsche Affinerie AG; Kansallis-Osake-Pankki (KOP) of Finland agreed to provide US$47 million, and 50 000 t/y of concentrates will go to Outokumpu Oy. The decision by Finland to provide financing and take concentrates provoked controversy in Finland.

Neither the Escondida owners nor the smelters released details on contracted treatment and refining charges (TCRCs) for the concentrates. The startup of Escondida will help tip the balance between concentrate shippers and custom smelters in favour of the smelters during the early 1990s. Consequently, Canadian copper concentrate exporters will be adversely affected by its start up, but Canadian custom smelters will benefit from any general increase in TCRCs. To some extent, TCRCs have already increased in anticipation of new supply.

In early 1989, Cia Minera Disputada de las Condes SA is expected to announce a program to increase production at its Los Bronces mine, from the current level of 40 000 t/y to 120 000 t/y by late 1991.

In **Peru** two nation-wide miners' strikes dominated events in the copper industry. After a month-long summer strike the unions called a second strike on October 17 to enforce tentative settlements obtained in August. The second strike lasted until December when the union dropped demands that wages be tied to the inflation rate, instead asking for regular raises starting in January. Inflation in Peru ran at about 1100 percent in 1988. Peruvian mine owners estimated the strike-related production losses at 100 000 t of copper valued at US$242 million. Peruvian copper production likely declined to about 300 000 t in 1988, compared to 395 000 t in 1987. The government began preparation of international tenders to develop the second stage of the Cerro Verde copper mine. The program envisages production of 26 700 t/y of copper in concentrates beginning in late 1990.

In August, the **Brazilian** government sold the smelting and refining facilities of Caraiba Metais S.A. for US$86 million. The owners plan an expansion from 160 000 t/y to 250 000 t/y by 1992. Construction should start in early 1989. Marvin S.A., one of the buyers, announced after the purchase that it had shelved plans for a 70 000 t/y fire refinery in Rio de Janeiro until at least 1992. But Cia. Paraibuna de Metais SA (CPM), another of the buyers, continued planning for a 100 000 t/y smelter and refinery in Maranhao state, to start up in two phases. CPM hopes to take concentrates for its operation from the future Salobo mine. However, due to financial constraints, Companhia Vale do Rio Doce (CVRD) apparently plans a more modest operation at Salobo, a US$500 million mine producing only 80 000 t/y copper in concentrates.

In **Japan** consumption rose faster than forecasted, forcing firms to purchase spot material. Revised forecasts in October showed both brass and wire production reaching record levels in fiscal 88/89, at 0.432 Mt and 1.024 Mt, respectively. Japanese smelting/refining companies stepped up their production from 76 000 t/m to 86 000 t/m in the fall. They also secured significant amounts of long term concentrates from the Escondida mine in Chile, the Neves Corvo mine in Portugal and elsewhere.

In **India,** Hindustan Copper Ltd. asked that Indian copper prices be based on production costs rather than a multiple of LME prices. The five-year plan calls for copper production to be expanded to 97 000 t by 1995.

Pakistan and China's Metallurgical Construction Corp. agreed to develop the Saindak deposit. The government of Pakistan has spent about US$80 million over the last decade in exploring the 400 Mt deposit in Baluchistan province. China will contribute US$84 million in credits out of the US$180 million construction cost. In return, Pakistan will pay China in blister copper from the 15 000 t/y to be produced at Saindak.

In the **People's Republic of China** copper exports increased sharply leaving some domestic fabricators idle for lack of raw materials. Chinese copper production in 1987 was 516 000 t compared to consumption of 820 000 t. In July the government restricted exports of copper and copper containing goods. At year end the government announced a ban on the export of copper and copper alloys. The Chinese Nonferrous Metal Industry Corp. is considering a US$300 million investment in the Philippines to obtain 100 000 to 200 000 t/y of copper concentrates.

In the **Republic of Korea,** 1988 copper consumption is estimated at 300 000 t, compared to 265 000 t in 1987. Expansion of the Outokumpu flash smelter at Onsan from 100 000 t/y to 140 000 t/y was scheduled for completion by year end. Onsan became the site of the world's largest copper and copper-alloy fabrication facility, when Poongsan Metal completed its expansion to 254 000 t/y in 1987.

In **Papua New Guinea,** labour troubles affected the country's two copper mines. Bougainville Copper Limited was shut down twice, losing 4 100 t of copper in concentrates due to bomb attacks. Bougainville will install in-pit crushing and conveying facilities in an expansion from 48 Mt/y to 52 Mt/y to counteract the decline in grade. Bougainville produces about 175 000 t/y of copper in concentrates.

At the Ok Tedi operation, three strikes shut the mine during the year. By December the new primary ore crusher was commissioned, allowing the mine to produce at a rate of 500 000 t/y of concentrates containing 150 000 t/y of copper plus gold. In the first nine months the mine produced 34 000 t of copper in concentrates compared with 39 000 t for all of 1987.

In **Indonesia** the outlook for Freeport-McMoRan Copper Company, Inc.'s operations continued to improve. The company continued raising production to reduce costs. It should reach 23 500 t/d by the end of 1989. In early 1988, Freeport discovered the Grasberg prospect only a few kilometres from existing operations. The deposit contains 92 Mt of indicated proven and probable ore grades at an average of 1.45% Cu with 1.52 g/t Au and 2.44 g/t Ag. The company likely can use existing infrastructure to mine the new deposit. With the Grasberg deposit potentially doubling the ore reserves, the company began studying plans to expand production to 45 000 t/d.

In **Australia,** the Olympic Dam project formally commenced operations in November. The A$750 million joint venture will initially produce 45 000 t of refined copper, 1 500 t/y of uranium oxide, 17 t of silver and 840 kg of gold. Financing arrangements between partners Western Mining Corporation and BP require BP to eventually arrange for financing to increase production to 150 000 t/y of copper and 4 000 t/y of uranium.

CRA Limited decided to rehabilitate the Port Kembla operations of its subsidiary Electrolytic Refining & Smelting Co. of Australia Ltd. (ER&S). CRA opted for a Noranda reactor able to produce 80 000 t/y anode copper, to double the capacity of the existing blast furnace. ER&S will have to source the additional concentrates offshore. Additional tankhouse facilities and an acid plant will also be completed by late 1990.

Difficult financial conditions still faced copper producers in the **Philippines** but production for the first nine months of 1988 was 167 270 t, up from 160 085 t in the same period in 1987. Higher prices have allowed some producers to consider expansions and debt reduction, but there is a dispute with the government about back taxes. The government issued new investment rules for foreign companies in the mining sector: foreign companies will be allowed to take up to 40% of the equity. The government plans to privatize state-owned copper operations, including Philippine Associated Smelting and Refining Corp. (PASAR) and two copper mines. PASAR intends to expand its capacity from 138 000 t/y to 172 500 t/y. The company also talked of building a copper fabrication plant at the site.

In **South Africa,** Palabora Mining Co. Ltd. (PMC) installed a con-top cyclone on the smelter in the first quarter. It increases smelter throughput to match the refinery capacity of 140 000 t/y. An in-pit crusher and conveyor were installed to reduce truck haulage requirements.

A consultant's report released in January 1988 proposed a staged reactivation of the railway running from Zaire to the port of Lobito in Angola. The 1350 km rail line has been closed since 1975 due to the civil war in Angola. The closure increased the transportation time and costs of shipping copper from Zaire and increased both Zambia's and Zaire's dependence on rail links through Dar-Es-Salaam and South Africa.

In **Zambia,** production declined in 1988 compared to 1987 despite increased copper prices. For the first nine months of 1988, production totalled 312 500 t compared with 369 300 t for the same period of 1987. The expected production from Zambia for calendar 1988 is 425 000 t, assuming fourth quarter production matches that of 1987. In late December, the government approached the International Monetary Fund (IMF) to approve a plan for economic recovery. Zambia had rejected IMF conditions for economic assistance in 1986, making it difficult for Zambia to obtain foreign currency. Zambia Consolidated Copper Mines Limited (ZCCM) has reportedly planned to reduce its 1989 exports due to a lack of capital investments funds.

Générale des Carrières et des Mines (Gécamines) of **Zaïre** announced that the country's copper exports for 1988 should total between 505 000 t and 510 000 t. The company also announced its intention to commence production of high grade cathodes at the rate of 40 000 t/y in 1991 or 1992 from a new refinery to be built. Final refinery capacity should be 100 000 t/y.

In **Portugal,** the Neves Corvo mine commenced operations in late 1988. Production in 1989 is targeted at 330 000 t of copper concentrates grading 25% copper, rising to the design level of 500 000 t/y in 1990. When an associated tin project commences production, it could add an additional 100 000 t/y of copper concentrates to the mine's production. In December, the government speculated that production could eventually reach 800 000 t/y of concentrates. Noranda, Rio Tinto Minera SA of Spain, Norddeutsche Affinerie and a Japanese group headed by Sumitomo Metal Mining Co. Ltd. contracted for 75% of the Neves Corvo output.

In **Finland,** Outokumpu Oy became an independent company as of the start of 1989. One of its subsidiaries, Outokumpu Copper Ltd., will hold all the copper properties and copper processing facilities.

RECYCLING

Much of the copper used is eventually recycled. In 1987, the western world produced about 6.7 Mt of copper from primary sources and recovered about 1.1 Mt from secondary sources. A further 2.8 Mt of copper was remelted (i.e. new scrap in industrial plants) in 1987.

Brass mills use scrap for a significant portion of their feed. U.S. copper and brass fabricators filed a petition for relief under Section 301 of the U.S. Trade Act of 1974. The fabricators claim that restrictions on copper and brass scrap exports by other countries artificially lower raw material costs in those countries. Citing damages of US$150 million/y, U.S. fabricators asked for negotiations to end the European Community scrap quotas (in place since 1971).

CONSUMPTION AND USES

Copper's high electrical and thermal conductivities combined with its tensile strength (160 MPa), elevated melting point (1083°C), non-magnetic properties and resistance to corrosion make it very attractive for electrical transmission, water tubing, castings and heat exchangers. It is the most efficient conductor of electrical power, signals and heat of all of the industrial metals. (Aluminum's electrical and thermal conductivities are only 72% and 76%, respectively, of copper's). Of the 8 Mt of copper used in semi-manufacture production in the western world in 1987, about 60% was used in the fabrication of wire.

In Canada, the government does not collect copper consumption statistics. The Canadian Copper and Brass Development Association (CCBDA), an association of producers and fabricators, collects certain statistics for its members. The CCBDA disseminates information to copper users and provides technical assistance to encourage and foster copper consumption in Canada. Besides the traditional uses, copper is consumed in Canada for retro-fitting of fire suppression systems, natural gas tubing in residences, central vacuuming, and roofing. Changes are being contemplated that would require fire suppression systems in all new residential dwellings; copper is the preferred material for such systems.

The U.S. has the best public copper consumption data. Table 8 presents the end use data for 1986 collected by the U.S. Copper Development Association Inc. (US CDA). These clearly indicate the importance of the construction market to copper consumption. The building wire and plumbing and heating sectors used over 31% of copper mill shipments in 1986. The average new U.S. house contains about 100 kg of copper in wire. Usage is rising as houses grow in size and incorporate more labour saving and other electrical devices. In a study completed in the early 1980s, the US CDA determined that about 165 kg of copper in all forms were required to build an average 150 m^2 (1700 $ft.^2$) house. A 90 m^2 (1000 $ft.^2$) multiple dwelling consumed 113 kg. Renovations also increase copper consumption when kitchen and plumbing facilities are brought up to modern standards.

The automotive industry consumes over 10% of U.S. copper and copper alloy shipments. While copper use in radiators has declined due to market penetration of aluminum radiators, the increased use of copper in electrical circuits has more than offset declining non-electrical copper consumption in vehicles. The typical vehicle in the United States had 450 electrical circuits in 1975 and about 900 circuits in 1988, and this is expected to rise to about 1200 in 1992. The average U.S. vehicle contained about 22 kg of copper and copper alloys in 1986, up from 16 kg in 1980. Automotive demand for copper is expected to continue to increase through the 1990s.

In 1986, telecommunications was the third largest market in the United States. This market has declined, principally due to technological advances. While the effect of fibre optics is widely publicized, fibres do not yet compete with copper where 80% of the copper in the phone system is used - in the subscriber loop. However, multiplexing and reduction of gauge have reduced the amount of copper used per phone circuit. Fibre optics is expected to gain a firm foothold in the subscriber loop in the 1990s and hence telecommunications will diminish even more quickly as a market for copper than in the 1970s and 1980s.

Some of the fibre optics applications are in markets that copper has already lost. Satellites and microwave stations handle much of the long haul telecommunications. In December 1988, the first trans-Atlantic fibre optics cable TAT-8 went into service and is capable of handling 40 000 simultaneous conversations. (TAT-7, a copper cable with an 8500 conversation capacity installed in 1983, will remain in service.) A Trans-Pacific fibre optics cable should be in operation in April 1989.

There have been advances in superconductivity at higher temperatures, but practical high current superconductors for industrial loads have not yet appeared. Long haul superconductors should first compete with overhead high tension wires, presently made of aluminum. If superconductors make electrical power more accessible and cheaper, the increased use of electrical motors should increase overall demand for copper.

Substitutes for copper include aluminum in electrical and thermal transfer applications, plastics in tubing applications and fibre optics for telecommunications. Since 1974, copper has retaken some of the share of the insulated conductor market previously lost to aluminum. But electrically conductive plastics are now being investigated, for example in household appliances.

Table 7 shows western world copper consumption in 1987; the United States ranks first. The developed countries (Western Europe, United States, Japan, Canada, Australia and New Zealand) together consumed 82% of the western world's copper at the semi-manufacturing stage in 1987, down from 93% in 1973 and 87% in 1980, as other countries have developed local manufacturing industries and developed countries' economies matured. Consider just four of the newly industrializing countries (NICs): South Korea, Taiwan, Brazil and Mexico. These four countries have shown very rapid increases in copper and copper alloy fabrication. From 1974 to 1987, copper consumption in these four countries increased an average of 7.8%/y. For the developed countries, the growth rate has been lower, averaging 1%/y. The growth rate for all other countries of the western world averaged 6.7%/y.

In the past, copper-deficient industrialized countries have often adopted policies to encourage development of diverse supplies of raw materials via aid and assistance with financing. Such policies have been reinforced by tariffs, with no or low tariffs on raw materials but progressively higher tariffs on processed, semi-manufactured and manufactured goods.

About 1.5 Mt of copper in concentrates is traded yearly in the western world. Canada is the largest exporter, followed by Chile and Papua New Guinea. Blister and anode copper trade is about half that of concentrate, averaging about 700 000 t/y. Refined trade totals about 3 Mt/y. In all, the yearly trade of the three forms of copper totals about 5.1 to 5.3 Mt/y (with some double counting). Net east-west trade is relatively small, averaging about 5% of identified world copper trade.

MARKETS, PRICES AND STOCKS

Copper demand continued to grow strongly in 1988 while production problems restricted growth in supply. High prices continued through 1988. Industries in some countries ran near capacity, causing fears of renewed inflation. The high capacity utilization in many industries encouraged capital investments to increase productive capacity. The robust demand for copper has come largely from sustained capital spending, as the world replaces aging facilities. Demand growth in 1988 may have been restricted by supply -- with very low stocks, consumption can now only grow at the rate of production increase.

The market enters 1989 again with very low inventories but with more production scheduled to come on-stream. It appears that copper demand will be strong for the first half of 1989 at least. With aluminum prices again lower than copper prices, the threat of substitution away from copper is again a major concern.

Copper prices rose to new records both on the London Metals Exchange (LME) and in New York on the Commodities Exchange, Inc. (COMEX). On the LME Grade A copper traded between £1120 and a record £2006/t, or US$0.95 and $1.68/lb.; COMEX 1st position settlement prices ranged from US$0.875/lb. to a record $1.63/lb. The LME 3 month ask price for copper averaged US$1.09/lb., trading within a range of US$0.90/lb. to US$1.45/lb. Daily copper prices for the period 1986/88 are shown in Figure 1.

LME high grade aluminum prices surpassed LME Grade A copper prices from late February until mid-September, but then fell below copper. The volatile and higher price for aluminum undoubtedly assisted copper to retain its markets, even with the lofty copper prices. LME cash settlement aluminum prices peaked at US$1.85/lb.

Economic forecasts at the end of 1987 were coloured by the pessimistic mood following the severe stock market correction of October. Most forecasters underestimated economic growth and therefore copper demand. Forecasters were also too optimistic about planned increases in copper production in 1988. Thus the supply-demand balance did not shift into a significant surplus in mid-1988 as had been widely forecasted.

Combined LME and COMEX copper stocks increased from 69 712 t at the start of 1988 to 77 929 t at year end, but remained well below levels of recent years. End-of-week stocks rose to a high of 145 691 t on August 19 during the traditional summer period of slow copper consumption, but then declined as demand regained its vigour. Low stocks contribute to price volatility. Exchange stocks for 1986 to 1988 are shown in Figure 2.

The LME had revised the standard copper contract in 1987 to include fire refined material and Codelco-Chile material was listed effective April 1, 1988. But due to insufficient liquidity, the LME decided to delist the standard copper contract effective January 4, 1989. As well, COMEX introduced its new high grade contract at the end of July, reflecting the move by consumers to higher grade material. The change to the 99.99% pure copper had been approved in October 1986, but not then introduced. The first delivery month will be January 1989. COMEX will cease trading the standard copper contract in December 1989.

Although there were calls for the introduction of U.S. dollar denominated copper contracts, the LME chose to retain sterling prices for copper. This decision is to be reviewed in 1989.

INTERNATIONAL PRODUCER-CONSUMER FORUM

In June, the United Nations Conference on Trade and Development hosted a conference to negotiate the establishment of an intergovernmental producer-consumer forum or group for copper. Discussions centred around the functions of the group. The conference will be reconvened in early 1989, seeking to conclude negotiations to establish an autonomous producer-consumer forum or group. One of the benefits of such a group would be more timely and accurate statistics, especially with respect to consumption. Present data reflect manufacturing activity rather than how copper is finally consumed. This in turn hinders market promotion activities as it is more difficult to quantify end uses and to monitor effects of promotion.

HEALTH, SAFETY AND THE ENVIRONMENT

Mankind's health depends upon an adequate dietary intake of copper (as it does on many other trace metals). Copper combines with proteins to form many enzymes critical for life. One such important enzyme is superoxide dismutase which removes the superoxide radicals in the body. Superoxide radicals are the "residues" of metabolic processes which could build up to toxic levels unless removed. Copper is also required to transport iron from absorption sites to the bone marrow where red blood cells are produced.

Many regulatory agencies have chosen 1 ppm as the maximum desirable concentration of copper in drinking water. It signifies more an aesthetic than a health limit: water containing more than 1 ppm can stain laundry, and persons with a keen sense of taste may perceive a metallic flavour in the water.

Copper tubing used for distribution of potable water supplies has beneficial bactericidal characteristics. It has been noted, for example, that the **Legionnella pneumonillia** bacteria causing Legionnaires's disease and Pontiac fever were present in many hotel systems but not in those with copper water systems.

Like most metals, copper is found in small concentrations in nature. The mining of copper generates significant amounts of solid wastes, in tailings ponds and to a lesser extent in rock dumps. Due to associated minerals such as pyrites in the ore, the wastes generate acid when exposed to oxygen in the air. Commonly, mine operators control acid generation by keeping the tailings areas below the water table and covering acid generating waste with soil.

Most of the environmental concerns that arise from producing copper are associated with the sulphur dioxide emissions that result from copper smelting. In Canada, Noranda will close the reverberatory furnace at its Horne smelter in early 1989 while an acid plant is completed. By 1990, Noranda should have the option of reopening the reverberatory furnace, depending upon feed availability and treatment and refining charges. In Ontario, INCO will spend $69 million to rationalize milling operations and to reduce some sulphur input to the smelting process by selective rejection of iron sulphide. INCO will spend a further $425 million to reduce sulphur emissions from its Sudbury copper and nickel smelters. Falconbridge will spend $38 million to reduce emissions at its smelter in Sudbury.

In the United States, Magma completed a flash smelter and acid plant to replace its reverberatory furnaces, in order to meet U.S. environmental regulations. In Chile, Codelco-Chile completed a new flash smelter and acid plant which replaces some of the existing reverberatory smelting capacity at Chuquicamata, and built an acid plant at El Teniente.

OUTLOOK

As demand in 1988 was higher than anticipated and expected production increases did not materialize, almost all price forecasts fell short of actual prices. Interestingly, many price forecasts for 1989 resemble those for 1988: high prices in the first half of the year, but declining thereafter.

Western world copper demand increased to about 8.4 Mt in 1988, up 1 Mt on 1985 and 1.5 Mt on 1982. With additional production scheduled to begin in 1989 and beyond, prices should decline significantly unless copper demand continues at recent growth rates.

There are two major uncertainties for the copper industry in 1989 -- whether growth rates for copper demand will be maintained, and the possibility of production interruptions in the United States and Chile. Interest rates are forecast to increase in 1989, which may lead to a slowing of residential construction and automotive purchases, two very important markets for copper. In North America, about 700 000 t/y of primary mine copper production occurs at plants where labour contracts expire in 1989. In the United States, at the last contract negotiations in 1986 when prices were very low, workers agreed to wage reductions in the order of 20 to 25%. In 1989, workers in the United States can be expected to ask for significant increases; likely the companies will attempt to have the increased compensation tied to copper prices. Copper price-related bonuses were distributed to workers during 1988, even at operations where this was not required, such as Ray mine and at Bingham Canyon. In Chile, a presidential election is scheduled for 1989. Analysts have expressed concern that political turmoil might result in production losses in Chile.

Assuming no significant strike-related production losses in 1989 and that demand remains above 8.1 Mt, the price of Grade A copper on the LME is forecast to average $1.05/lb., being higher in the first half and declining as new production comes on-stream and as higher interest rates slow economic activity. But with the low stocks, price volatility will continue in 1989. Prices could trade in the range of $1.70 to $0.85.

Nineteen hundred and eighty nine will be an important year for the future of the copper producers. Some existing producers have total costs amounting to less than half of their revenues. Continued higher prices in 1989 will see increased exploration expenditures, important to maintain future production in Canada and elsewhere. But the longer the prices remain high, the more predisposed investors and bankers will be to funding projects that depend on the higher prices to be economic. Once copper prices dip again, the surfeit of production capacity can prolong the period of depressed prices. New projects tend to be larger and less amenable to temporary closure during periods of low prices.

Since 1965, monthly average LME copper prices averaged 0.615 Special Drawing Rights/lb. (SDR/lb.) (Figure 3). The SDR is an international currency basket made up of the currencies of the United States, Japan, France, Federal Republic of Germany and the United Kingdom. As copper is an internationally traded commodity, use of such a currency basket for price tends to moderate the variations of an individual currency. But since 1980, the range has shifted upwards and averaged 0.66 SDR/lb. In both these periods, the market has expressed shortages and high prices followed by oversupply with stock build-up and low prices. Such periodic supply-demand mismatches are likely to continue in the 1990s.

An average price of US90¢/lb. during the 1990s is forecast, based on a U.S. dollar value of $US1.35 = 1 SDR. Figure 3 clearly shows that 1988 prices are above historical levels.

TARIFFS

Item No.	Description	Canada			United States	EEC	Japan[1]
		MFN	GPT	USA	Canada	MFN	MFN
2603.00.00	Copper ores and concentrates	Free	Free	Free	Free	Free	Free
2603.00.00.10	-----Copper content	Free	Free	Free	Free	Free	Free
2825.50.00	-Copper oxides and hydroxides	Free	Free	Free	3.1 to 4.0%	3.2%	7.2%
28.33	Sulphates; alums; peroxosulphates -Sodium sulphates:						
2833.25	--Of copper						
2833.25.10.00	---Cupric sulphate	6.8%	Free	5.4%	1.1%	3.2%	5.8%
74.01	Copper mattes; cement copper (precipitated copper)						
7401.10.00.00	-Copper mattes	Free	Free	Free	0.5¢/kg on copper content	Free	Free
74.03	Refined copper and copper alloys, unwrought -Refined copper						
7403.11.00.00	--Cathodes and sections of cathodes	Free	Free	Free	0.8%	Free	21 yen/kg
7403.12.00.00	--Wire-bars	4%	Free	3.2%	0.8%	Free	21 yen/kg
7403.13.00	--Billets	Free	Free	Free	0.8%	Free	21 yen/kg
7403.19	--Other						
7403.19.10	---Ingots, ingot-bars and slabs	Free	Free	Free	0.8%	Free	21 yen/kg
7403.21	--Copper-zinc base alloys (brass)						
7403.21.10	---Ingots, ingot-bars, slabs and billets	4%	Free	3.2%	0.8%	Free	21 yen/kg
7403.22.00	--Copper-tin base alloys (bronze)	10.3%	6.5%	8.2%	0.8%	Free	21 yen/kg
7404.00	Copper waste and scrap						
7404.00.10.00	---Not alloyed	Free	Free	Free	Free	Free	Free
	---Alloyed						
7404.00.21.00	----Copper-zinc base alloys (brass)	4%	Free	3.2%	Free	Free	Free
7405.00.00.00	Master alloys of copper	10.3%	6.5%	8.2%	2% to 4.8%	Free	6.0%
74.06							
7406.10	-Powders of non-lamellar structure						
7406.10.10	---Not alloyed	4%	Free	3.6%	4.8%	1.4%	7.2%
7406.20	-Powders of lamellar structure; flakes						
7406.20.10	---Not alloyed	4%	Free	3.6%	2.7%	6.2%	7.2%
74.07	Copper bars, rods and profiles						
7407.10	-Of refined copper ---Unworked						
7407.10.11.00	----Bars and rods, of a maximum cross-sectional dimension not exceeding 12.7 mm	4.5%	3%	4%	0.9%	6.0%	7.2%

Item No.	Description	Canada			United States	EEC	Japan[1]
		MFN	GPT	USA	Canada	MFN	MFN
	-Of copper alloys						
7407.21	--Of copper-zinc base alloys (brass)						
	---Unworked						
7407.21.11.00	----Bars and rods, of a maximum cross-sectional dimension not exceeding 12.7 mm	4.5%	3%	4%	1.7% to 2.8%	6.0%	7.2%
7407.21.12	----Bars and rods, of a maximum cross-sectional dimension exceeding 12.7 mm; profiles	4%	Free	3.6%	1.7% to 2.8%	6.0%	7.2%
74.08	Copper wire						
	-Of refined copper:						
7408.11	--Of which the maximum cross-sectional dimension exceeds 6 mm						
	---Not exceeding 12.7 mm:						
7408.11.11.00	----Not coated or covered	4.5%	3%	4%	0.9% to 3.6%	6.0%	7.2%
	---Exceeding 12.7 mm						
7408.11.21.00	----Not coated or covered	4%	Free	3.6%	0.9% to 3.6%	6.0%	7.2%
74.09	Copper plates, sheets and strip, of a thickness exceeding 0.15 mm						
	-Of refined copper						
7409.11	--In coils						
7409.11.10	---Unworked	4%	Free	3.6%	6.0%	6.0%	6.5%
7409.19	--Other						
7409.19.10	---Unworked	4%	Free	3.6%	4.2%	6.0%	6.5%
	-Of copper-zinc base alloys (brass):						
7409.21	--In coils						
7409.21.10	---Unworked	4%	Free	3.6%	1.7%	6.0%	6.0%
7409.29	-Other						
7409.29.10	---Unworked	4%	Free	3.6%	1.7%	6.0%	6.0%
74.10	Copper foil (whether or not printed or backed with paper, paperboard, plastics or similar backing materials) of a thickness (excluding any backing) not exceeding 0.15 mm						
	-Not backed:						
7410.11	--Of refined copper						
7410.11.10	---Unworked	4%	Free	3.6%	0.9%	6.5%	6.0%

74.11	Copper tubes and pipes						
7411.10	-Of refined copper						
7411.10.10	---Unworked	4%	Free	3.6%	1.3%	6.0%	6.5%
	-Of copper alloys:						
7411.21	--Of copper-zinc base alloys (brass)						
7411.21.10	---Unworked	4%	Free	3.6%	1.2%	6.0%	6.5%
74.12	Copper tube or pipe fittings (for example, couplings, elbows, sleeves)						
7412.10.00	-Of refined copper	10.3%	6.5%	9.2%	10.0%	6.5%	5.8%
7412.20.00	-Of copper alloys	10.3%	6.5%	9.2%	2.8%	6.5%	5.8%
7413.00.00	Stranded wire, cables, plaited bands and the like, of copper, not electrically insulated	10.3%	6.5%	9.2%	3.6% to 5.1%	Free to 6.5%	7.2%
74.15	Nails, tacks, drawing pins, staples (other than those of heading No. 83.05) and similar articles, of copper or of iron or steel with heads of copper; screws, bolts, nuts, screw hooks, rivets, cotters, cotter-pins, washers (including spring washers) and similar articles, of copper						
7415.10.00	-Nails and tacks, drawing pins, staples and similar articles	10.3%	6.5%	9.2%	4.5%	6.5%	5.8%
	-Other threaded articles:						
7415.31.00.00	--Screws for wood	10.2%	6.5%	9.1%	4.9%	4.9%	5.8%

Sources: Customs Tariffs, effective January 1989, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States (First Edition Supplement 2) effective January 1, 1989; Official Journal of the European Communities, Vol. 30, No. L256, 1987, "Conventional" column; Custom Tariff Schedules of Japan, 1988.

[1] GATT rate is shown, lower tariff rates may apply circumstantially.

NOTE: Where there is a tariff "range" a complete match of the HS code was not available, therefore, the high and low for the product in question is shown.

TABLE 1A. CANADA, COPPER PRODUCTION, TRADE AND CONSUMPTION, 1985-87

	1985		1986		1987	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Shipments[1]						
Nova Scotia	-	-	-	-	x	x
New Brunswick	6 774	13 454	6 298	12 860	7 233	17 515
Quebec	73 531	137 175	51 622	105 412	66 848	161 877
Ontario	284 692	565 398	264 870	540 865	287 354	695 844
Manitoba	69 071	146 032	65 369	133 483	66 121	160 115
Saskatchewan	4 976	9 882	3 506	7 160	2 335	5 654
British Columbia	299 560	594 926	306 855	626 598	364 134	881 772
Yukon	10	19	6	13	x	x
Northwest Territories	23	46	1	1	2	4
Total	738 637	1 466 932	698 527	1 426 392	794 149	1 923 080
Refinery output	499 626	..	493 445	..	491 178	..
Exports						
Copper in ores, concentrate and matte						
Japan	237 869	340 177	253 686	365 723	273 536	452 381
People's Republic of China	16 026	26 488	24 491	34 853	25 861	36 083
Taiwan	29 582	40 690	20 675	30 150	19 932	26 489
South Korea	4 415	6 481	14 007	20 248	15 981	26 380
Norway	28 076	45 282r	20 223	33 164	13 615	20 301
Spain	-	-	3 703	4 057	12 524	19 872
Finland	-	-	-	-	8 037	10 771
Brazil	2 355	3 266	-	-	3 521	5 982
West Germany	-	-	-	-	3 528	4 870
Belgium-Luxembourg	1 005	610	1 085	542	3 524	3 758
United Kingdom	897	1 639	870	1 564	845	1 673
United States	394	74	2 650	3 851	222	34
Total	320 619	464 707r	341 390	494 152	381 126	608 593
Copper in slag, skimmings and sludge						
Italy	322	152	250	100	-	-
United States	3 449	951r	1	7	-	-
Total	3 771	1 103r	251	107	-	-
Copper scrap (gross weight)						
United States	26 094	39 148r	29 530	50 069	35 758	64 707
South Korea	835	1 178	1 213	1 735	1 372	2 828
Japan	607	772	1 131	1 708	1 315	2 156
West Germany	2 980	4 740	8 625	10 135	1 024	1 497
Brazil	-	-	220	461	356	662
Other countries	9 021	12 951	3 099	4 494	2 241	2 657
Total	39 537	58 789	43 818	68 602	42 066	74 507

Brass and bronze scrap (gross weight)						
United States	9 215	11 227	12 285	15 462	13 609	18 426
West Germany	1 908	2 364	822	1 115	2 037	2 569
India	537	454	932	787	1 517	1 290
United Kingdom	199	342	401	392	727	971
Brazil	40	46	786	1 392	606	919
Taiwan	475	573	901	1 067	734	866
South Korea	92	106	319	399	617	811
Japan	155	120	246	288	460	701
Belgium-Luxembourg	1 149	1 501	441	525	273	337
Netherlands	429	553	359	540	183	215
Italy	1 849	2 261	1 831	2 239	186	[illegible]
Other countries	199	214r	122	154r	375	406
Total	16 247	19 838	19 445	24 361	21 324	27 711
Copper alloy scrap, n.e.s. (gross weight)						
United States	4 311	4 224	5 637	5 672	6 395	7 143
Other countries	2 378	2 950	1 107	1 122	2 013	2 582
Total	6 689	7 174	6 744	6 794	8 408	9 725
Copper refinery shapes						
United States	135 488	258 792	193 597	380 517	197 808	451 470
United Kingdom	42 044	80 856	53 984	104 047	39 380	85 740
Sweden	9 699	18 550	9 708	18 869	9 619	21 537
Italy	4 306	8 151	8 786	17 393	9 257	21 172
West Germany	18 151	32 244	15 038	29 477	7 760	17 030
France	10 431	19 653	4 315	8 360	6 168	14 825
Netherlands	25 060	42 733	8 030	14 986	8 193	14 508
Belgium-Luxembourg	8 866	17 155	6 246	11 145	4 102	10 379
People's Republic of China	24 063	40 921	5 300	10 053	3 995	8 981
Portugal	540	1 032	1 800	3 317	1 050	2 489
Other countries	1 385	2 839	18	52	1 468	3 614
Total	280 033	524 926	306 822	598 218	288 800	651 746
Copper bars, rods and shapes, n.e.s.						
United States	11 549	27 780	12 057	29 302	10 519	27 884
India	49	88	361	696	1 954	3 693
Venezuela	1 303	2 765	1 486	3 363	1 462	3 182
Belgium-Luxembourg	-	-	-	-	1 030	2 839
Other countries	6 569r	13 297r	4 716	10 158	2 342	4 720
Total	19 470	43 930	18 620	43 520	17 307	42 318
Copper plates, sheet and flat products						
United States	4 802	16 173	3 750	12 607	4 468	15 884
West Germany	-	-	-	-	366	1 101
Other countries	3 504r	6 433r	274	804	138	434
Total	8 306	22 606r	4 024	13 411	4 972	17 419

TABLE 1A. (cont'd)

	1985		1986		1987	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Exports (cont'd)						
Copper pipe and tubing						
United States	4 816	14 391	5 715	17 590	5 541	20 277
Israel	707	1 954	524	1 549	677	2 027
Other countries	154	466	360	1 620	637	2 757
Total	5 677	16 811	6 599	20 759	6 855	25 061
Copper wire and cable (not insulated)						
United States	196	623	466	1 300	486	1 364
Dominican Republic	-	1	-	-	207	594
Mexico	18	43	163	355	216	578
People's Republic of China	-	-	-	-	48	66
New Zealand	1	6	-	-	9	58
Other countries	149	541	204	533	47	107
Total	364	1 215	833	2 208	1 013	2 767
Copper alloy shapes and sections						
United States	12 928	36 822	16 890	40 609	21 017	56 460
Other countries	98	275	16	109	369	915
Total	13 026	37 097	16 906	40 718	21 386	57 376
Copper alloy pipe and tubing						
United States	3 612	12 884	1 686	7 866	1 797	7 632
Other countries	79	243	30	155	112	474
Total	3 691	13 127	1 716	8 021	1 909	8 106
Copper alloy wire and cable (not insulated)						
United States	327	898	109	467	193	494
Other countries	13	92r	31	136	15	162
Total	340	989	140	603	208	655
Copper and alloy fabricated materials, n.e.s.						
United States	1 306	4 943	971	4 662	1 353	5 521
Other countries	334	798	307	1 212	122	929
Total	1 640	5 741	1 278	5 874	1 475	6 451
Total copper exports	..	1 218 053	..	1 327 345	..	1 532 435

Copper Imports						
Copper scrap	77 749	90 928	59 291	78 789	64 302	85 612
Copper in ores and concentrates	76 137	66 139	70 674	73 334	50 510	83 929
Copper alloy scrap	7 454	8 780	6 476	8 163	5 023	7 583
Copper oxides and hydroxides	270	759	463	1 179	622	1 732
Copper sulphate	1 381	1 102	3 849	3 056	4 591	3 384
Copper, refinery shapes	19 131	39 409	20 901	42 579	16 583	34 598
Copper bars, rods and shapes, n.e.s.	5 656	12 583	7 113	16 224	14 665	34 477
Copper plates, sheet and flat	4 820	13 494	2 921	8 725	2 869	8 606
Copper pipe and tubing	3 424	12 029	2 734	9 852	3 116	11 084
Copper wire and cable (not insulated)	3 949	15 327	3 816	15 095	5 641	20 432
Copper powder	747	1 919	976	2 392	833	2 370
Copper alloy refinery shapes	11 428	28 559	13 288	33 529	16 794	41 924
Brass plates, sheet, strip, etc.	4 002	12 836	5 738	18 395	5 474	16 647
Copper alloy plates, sheet, etc.	1 638	7 705	1 588	8 741	1 286	7 534
Copper alloy pipe and tubing	3 775	18 000	4 776	23 356	4 990	24 156
Copper alloy wire and cable (not insulated)	1 506	5 021	1 501	4 993	2 414	8 107
Copper alloy castings	551	3 628	741	4 851	689	4 234
Copper and copper alloy fab. materials	2 731	13 813	3 179	16 226	4 485	20 763
Valves, brass, n.e.s.	..	25 765	..	25 072	..	29 393
Pipe fittings, copper and copper alloy	..	18 129	..	19 532	..	26 777
Total copper imports	..	395 925	..	414 085	..	473 342

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Anode copper recovered in Canada from domestic concentrates plus exports of payable copper in concentrates and matte.

r Revised; - Nil; .. Not available or not applicable; n.e.s. Not elsewhere specified; x Confidential.

Note: Components may not add due to rounding.

TABLE 1B. CANADA, COPPER PRODUCTION AND TRADE, 1988P

	1988P	
	(tonnes)	($000)
Shipments[1]		
Nova Scotia	x	x
New Brunswick	9 607	30 847
Quebec	45 191	145 108
Ontario	256 629	824 034
Manitoba	53 304	171 160
Saskatchewan	2 509	8 057
British Columbia	353 406	1 134 787
Yukon	x	x
Northwest Territories	x	x
Total	721 588	2 317 018
Refinery output	518 200	..
Exports	**(Jan.-Sept.)**	
Copper ores and concentrates		
-----Copper content	253 662	545 852
Other ores and concentrates	6 630	5 538
-Copper oxides and hydroxides	20	29
Copper mattes; cement copper (precipitated copper)		
-Copper mattes	7 664	14 772
Refined copper and copper alloys, unwrought		
-Refined copper	193 381	550 779
-Other copper alloys	4 303	11 275
Copper waste and scrap	54 828	109 027
Master alloys of copper	96	294
Copper powders and flakes	248	1 265
Copper and copper alloy rods and profiles	10 772	30 869
Copper and copper alloy wire	1 629	5 942
Copper and copper alloy plates, sheets, strip and foil	14 503	49 764
Copper and copper alloy tubes and pipes	5 483	27 593
Copper and copper alloy tube and pipe fittings	..	12 146
Stranded wire, cables, plaited bands and the like, of copper, not electrically insulated	418	1 589
Cloth, fastener and other items of copper	..	11 549
Imports		
Copper ores and concentrates		
-----Copper content	29 093	55 682
Other ores and concentrates	13 211	8 498
-Copper oxides and hydroxides	714	1 886
Sulphates; alums; peroxosulphates (persulphates)		
-Sodium sulphates		
--Of copper	2 763	2 399
Copper mattes; cement copper (precipitated copper)		
-Copper mattes	144	65
Refined copper and copper alloys, unwrought		
-Refined copper		
-Other copper alloys	1 090	4 465
Copper waste and scrap	67 902	103 199
Master alloys of copper	11	63
Copper powders and flakes	865	3 632
Copper and copper alloy rods and profiles	29 626	86 817
Copper and copper alloy wire	16 117	57 997
Copper and copper alloy plates, sheets, strip and foil	11 002	41 207
Copper and copper alloy tubes and pipes	7 437	36 352
Copper and copper alloy tube and pipe fittings	4 023	27 316
Stranded wire, cables, plaited bands and the like, of copper, not electrically insulated	1 841	7 615
Cloth, fastener and other items of copper	..	15 250

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Anode copper recovered in Canada from domestic concentrates plus exports of payable copper in concentrates and matte.

P Preliminary; .. Not available or not applicable; x Confidential.

Note: Components may not add due to rounding.

TABLE 2. CANADA, COPPER PRODUCTION, TRADE AND CONSUMPTION, 1970, 1975, 1980 AND 1984-87

	Production		Exports			Imports	Consumption[2]
	Shipments[1]	Refinery Output	Concentrates and Matte +	Refined =	Total	Refined	Refined
				(tonnes)			
1970	610 279	493 261	161 377	265 264	426 641	13 192	229 026
1975	733 826	529 197	314 518	320 705	635 223	10 908	196 106
1980	716 363	505 238	286 076	335 022	621 098	13 466	208 590
1984	721 826	504 262	332 373	345 985	685 032	25 563	231 039
1985	738 637	499 626	320 619	280 033	600 652	19 131	203 335r
1986	698 527	493 445	341 390	306 822	676 212	20 901	204 685
1987	794 149	491 178	381 126	288 800	669 926	16 583	215 677

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Anode copper recovered in Canada from domestic concentrate plus exports of payable copper in concentrates and matte. [2] Producers' domestic shipments of refined copper plus imports of refined shapes.
r Revised.

TABLE 3. WESTERN WORLD MINE PRODUCTION OF RECOVERABLE COPPER IN CONCENTRATES, 1987 AND 1988

	1987	1988e
	(000 tonnes)	
Chile	1 420	1 432
United States	1 260	1 425
Canada[1]	794	721
Zambia[2]	500	500
Zaire	470	425
Peru	395	305
Australia	230	240
Papua New Guinea	217	230
Philippines	214	225
Other	1 000	1 047
Total	6 500	6 550

Sources: World Bureau of Metal Statistics; U.S. Bureau of Mines; Energy, Mines and Resources Canada. Data as available January 20, 1989.
[1] Data are for shipments. For comparison, estimated production in 1986, 1987 and 1988 was 745 000 t, 740 000 t and 720 000 t, while shipments were recorded at 699 000 t, 794 000 t and 721 000 t. [2] May include some or all of SXEW material from reprocessing of tailings.
e Estimated.

TABLE 4. WESTERN WORLD PRODUCTION OF REFINED COPPER[1] 1986 AND 1987

	1986	1987P
	(000 t)	
United States	1 560	1 600
Chile	972	1 000
Japan	980	1 000
Canada	491	520
Zambia[2]	508	490
Germany, Federal Republic	400	400
Belgium	352	350
Zaire	265	265
Peru	218	165
Other	1 854	1 910
Total	7 600	7 700

Sources: World Bureau of Metal Statistics; U.S. Bureau of Mines; Energy, Mines and Resources Canada. Data as available January 20, 1989.
[1] Includes primary, secondary and electrowon copper. [2] Includes some material from Zaire and likely also some or all of SXEW production.
P Preliminary.

TABLE 5. CANADIAN COPPER AND COPPER-NICKEL SMELTERS

Company and Location	Product	Rated Annual Capacity (tonnes of concentrates)	Blister or Anode Copper Produced in 1987[1] (tonnes)	Remarks
Falconbridge Limited Falconbridge, Ontario	Copper nickel matte	570 000	11 900	Fluid bed roasters and electric furnaces; 1 800 t/d sulphuric acid plant treats roaster gases. Matte from the smelter is refined in Norway.
INCO Limited Sudbury, Ontario	Molten "blister" copper, nickel sulphide and nickel sinter for the company's refineries; nickel oxide sinter for market, soluble nickel oxide for market	3 630 000[2]	118 000*[3]	Oxygen flash-smelting of copper concentrate; converters for production of blister copper. Roasters, reverberatory furnaces for smelting of nickel-copper concentrate, converters for production of nickel-copper Bessemer matte. Production of matte followed by matte treatment, flotation, separation of copper and nickel sulphides, then by sintering to make sintered-nickel products for refining and marketing. Electric furnace melting of copper sulphide and conversion to blister copper.
Falconbridge Limited, Timmins, Ontario	Molten "blister" copper	400 000	83 500*	Mitsubishi-type smelting, separation and converting furnaces, acid plant and oxygen plant to treat continuous copper concentrate feed stream to yield molten 99% pure copper which is transported by ladles and overhead cranes to two 350 t anode furnaces.
Noranda Inc. Horne smelter, Noranda, Quebec	Copper anodes	838 000	158 000	One oxy-fuel fixed reverberatory furnace, one continuous Noranda Process reactor and five converters; oxygen for the reverberatory furnace and Noranda reactor are supplied by two plants with a combined total of 540 t/d. Continuous reactor modified to produce matte instead of metal. Acid plant to be built and operational by end 1989. Reverberatory furnace to be closed in early 1989; Noranda may restart reverberatory furnace in 1990.
Noranda Inc. Gaspé smelter, Murdochville, Quebec	Copper anodes	215 000	60 000	One fluid bed roaster, one reverberatory furnace and two converters plus an acid plant. Treats Gaspé and custom concentrates.
Hudson Bay Mining and Smelting Co., Limited Flin Flon, Manitoba	Copper anodes	400 000	68 000	Five roasting furnaces, one reverberatory furnace and three converters. Company treats its own copper concentrate from mines at Flin Flon, Leaf Rapids and Snow Lake, as well as custom copper concentrates; zinc plant residues and stockpiled zinc-plant residues fed to reverberatory furnace.

---

[1] Smelter output as reported in corporate annual reports or by personal communication; if no smelter data available, then refinery output shown and indicated by "*" following number. [2] Includes copper and nickel-copper concentrates. This capacity cannot be fully utilized owing to Ontario government sulphur dioxide emission regulations. [3] Includes a small tonnage of copper from INCO's Manitoba operations.

TABLE 6. COPPER REFINERIES IN CANADA, 1987

Company and Location	Rated Annual Capacity	Output in 1987[1]	Remarks
	(tonnes)		
Noranda Inc. Division CCR East Montreal, Quebec	370 000	283 000	Refines anodes from Noranda's Horne and Gaspé smelters, from the Flin Flon smelter and also from purchased scrap. Copper sulphate and nickel sulphate recovered by vacuum evaporation. Precious metals, selenium and tellurium recovered from slimes. Produces CCR brand electrolytic copper cathodes, cakes and billets. Tankhouse modernization program announced 1988.
INCO Limited Copper Cliff, Ont.	180 000	118 000	Casts and refines anodes from molten converter copper from the Copper Cliff smelter; also refines purchased scrap. Gold, silver, selenium and tellurium recovered from anode slimes, along with platinum metals concentrates. Recovers and electrowins copper from Copper Cliff nickel refinery residue. Produces ORC brand electrolytic copper cathodes. Wirebar production ceased December 1987. Modernization program began in 1986 completed in 1988.
Falconbridge Limited Timmins, Ontario	92 000	83 500	Molten copper from two 350 t anode furnaces is cast in a Hazelett continuous casting machine into continuous copper strip, then formed to 145 kg anodes in a blanking press. Spent and scrap anodes are remelted in a 40 t ASARCO shaft furnace. Cathodes formed in jumbo sized electrolytic tanks in a highly automated tankhouse. A decopperized precious metal slime is also marketed.

---

[1] As reported in corporate annual reports or as advised by company.

TABLE 7. WESTERN WORLD CONSUMPTION OF REFINED COPPER, 1986 AND 1987

	1986	1987P
	(000 t)	
United States	2 202	2 135
Japan	1 219	1 285
Germany, Federal Republic	771	800
Italy	395	420
France	401	400
United Kingdom	340	328
Belgium	303	292
South Korea	262	259
Canada	205	216
Other	1 597	1 883
Total	7 695	8 018

Sources: World Bureau of Metal Statistics; U.S. Bureau of Mines; Energy, Mines and Resources Canada. Data as available January 20, 1989.
P Preliminary.

TABLE 8. TOP TEN MARKETS FOR COPPER IN THE UNITED STATES, 1986

	Mill Shipments	As % of Top Ten	As % of Market
	(000 t)		
Building wire	471	20.5	16.2
Plumbing and heating	457	19.9	15.7
Telecommunications	228	9.9	7.8
Electric power utilities	217	9.4	7.5
In-plant equipment	204	8.9	7.0
Air conditioning and refrigeration	200	8.7	6.9
Automotive electrical uses	200	8.7	6.8
Business electronics	117	5.1	4.0
Automotive - non-electrical uses	112	4.9	3.8
Industrial valves and fittings	95	4.1	3.3
Total of Top Ten Markets	2 301	100.0	79.0
Total U.S. market	2 914		

Source: United States Copper Development Association Inc.

TABLE 9. YEARLY AVERAGE COPPER PRICES[1]

Year	LME[1]
	(current US¢/lb.)
1979	90.1
1980	99.3
1981	79.5
1982	67.2
1983	72.2
1984	62.6
1985	64.9
1986	62.3
1987	80.1
1988	118.0

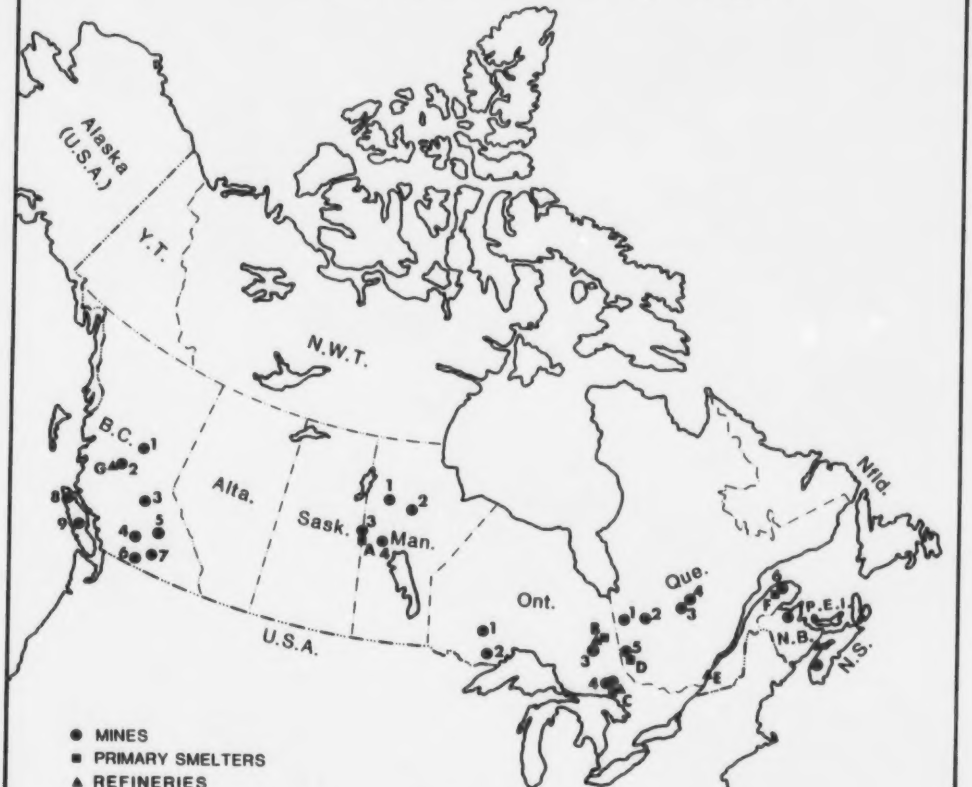
Source: "Metals Week."
[1] Settlement price for highest grade of copper sold.

TABLE 10. MONTHLY AVERAGE COPPER PRICES, 1987 AND 1988

	LME[1]		COMEX[2]	
	1987	1988	1987	1988
	(current US¢/lb.)			
January	61.1	120.8	60.8	123.2
February	62.6	105.7	61.7	99.7
March	66.5	107.0	63.6	103.9
April	67.3	103.9	62.4	97.5
May	69.0	111.0	66.5	99.3
June	71.3	115.2	69.9	109.0
July	76.9	100.4	76.2	98.8
August	79.7	99.8	77.6	96.2
September	82.1	110.5	81.0	111.2
October	89.2	133.3	83.0	133.5
November	114.5	149.9	103.9	147.1
December	130.1	158.7	127.5	155.8

Source: "Metals Week."
[1] LME settlement price for Grade A copper.
[2] COMEX First Position Settlement price.

COPPER IN CANADA, 1988


Alaska (U.S.A.)
Y.T.
N.W.T.
B.C.
Alta.
Sask.
Man.
Ont.
Que.
Nfld.
P.E.I.
N.B.
N.S.
U.S.A.
● MINES
■ PRIMARY SMELTERS
▲ REFINERIES

PRODUCERS IN 1988

(numbers and letters correspond to those on map "Copper in Canada 1988")

British Columbia

1. Noranda Inc. (Bell mine)
2. Equity Silver Mines Limited
3. Gibraltar Mines Limited
4. Highland Valley Copper[1]
5. Afton Mines Ltd.
6. Newmont Mines Limited
7. Brenda Mines Ltd.
8. BHP-Utah Mines Ltd.
9. Westmin Resources Limited

Saskatchewan

Hudson Bay Mining and Smelting Co., Limited

Manitoba

1. Hudson Bay Mining and Smelting Co., Limited (Ruttan mine)
2. INCO Limited (Thompson mine)
3. Hudson Bay Mining and Smelting Co., Limited, Flin Flon area mines
4. Hudson Bay Mining and Smelting Co., Limited, Snow Lake area mines

Ontario

1. Mattabi Mines Limited
   Noranda Inc. (Lyon Lake)
2. Noranda Inc. (Geco mine)
3. Falconbridge Limited, Timmins
   Pamour Inc.
4. Falconbridge Limited, Sudbury area
   INCO Limited, Sudbury area

Quebec

1. Les Mines Selbaie
2. Noranda Inc. (Mattagami Lake mine)
3. Minnova Inc. Opemiska Division
4. Westminer Canada Limited
   Campbell Resources Inc.
5. Audrey Resources Inc. (Mobrun mine)
6. Noranda Inc., Division Mines Gaspé

New Brunswick

Brunswick Mining and Smelting Corporation Limited

Nova Scotia

Rio Kemptville Tin Corporation

SMELTERS

A. Hudson Bay Mining and Smelting Co., Limited
B. Falconbridge Limited
C. INCO Limited
   Falconbridge Limited
D. Noranda Inc.
F. Noranda Inc., Division Mines Gaspé

REFINERIES

B. Falconbridge Limited
C. Falconbridge Limited
   INCO Limited
E. Noranda Inc., Division CCR
G. Gibraltar Mines Limited

---

[1] Highland Valley Copper is a partnership of Cominco Ltd., Lornex Mining Corporation Ltd. and Highmont Mining Corporation.

An inventory of undeveloped Canadian copper deposits is available in the publication "Canadian Mineral Deposits Not Being Mined in 1986", Energy, Mines and Resources Canada, Report MR 213, ISBN 0-660-12329-0.

For detailed production and ore grade information, refer to the table of Nonferrous Mines following the last commodity chapter.

Figure 1

LME COPPER PRICE - HIGHEST GRADE SOLD

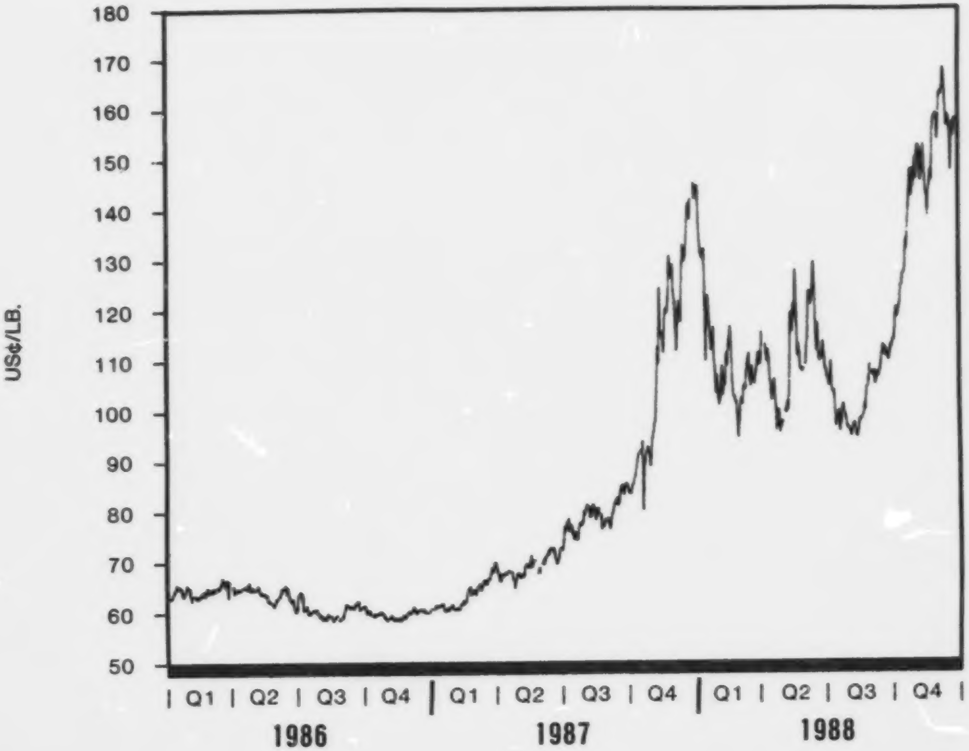


Figure 2

EXCHANGE STOCKS OF REFINED COPPER

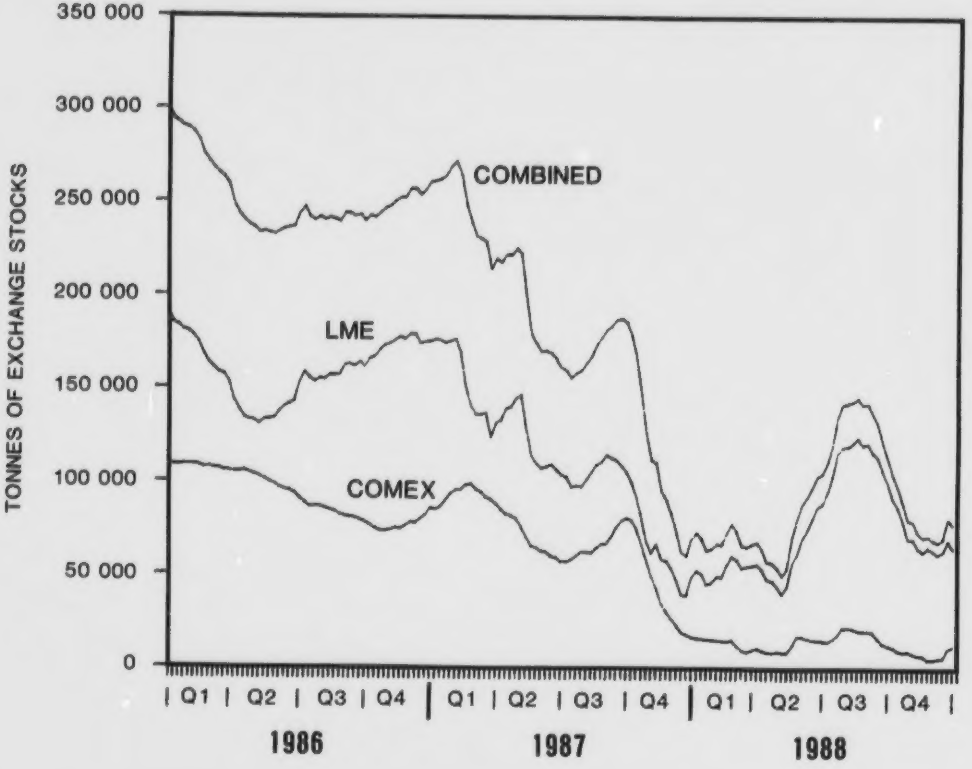
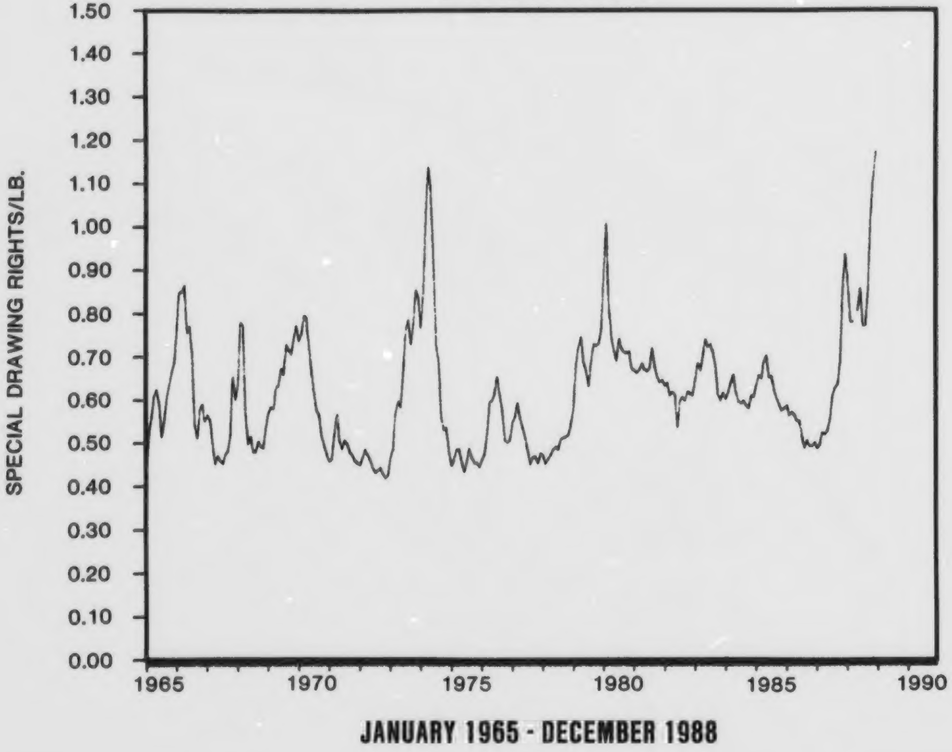


Figure 3

AVERAGE MONTHLY LME COPPER PRICES

CURRENT PRICES



Crude Oil and Natural Gas

R. THOMAS

International oil market prices continued to be soft and unstable throughout the year, which caused exploration activity to be strong in the first three quarters but drop significantly towards the close of the year. Members for the Organization of Petroleum Exporting Countries (OPEC) convened in December to seek an agreement upon individual production levels necessary to raise the price of crude. The organization targets the base selling price of crude oil at US$18 per barrel. Last year in mid-December, the price of West Texas Intermediate (WTI) was close to US$17/bbl. After the OPEC countries failed to adhere to agreed-upon production levels, this year WTI is selling for almost US$16/bbl. Prices of Canadian domestic crude "track" the marker crudes of the United States. In mid-December, the par price for light sweet crude (40° API and less than 0.5% sulphur) at Edmonton received C$109/m^3 (C$17.33/bbl.).

During the first nine months of 1988, many of the leading indicators of upstream activity (land sales, geophysical and drilling) were accelerating at levels surpassing those for 1986 and 1987. In the last quarter of the year, growth "stalled" as operators cut their exploration expenditures and concentrated on development of discovered prospects. Well completions are expected to surpass those for 1987 by close to 26%, reaching about 8 600 completions versus 6 800 wells and achieving an aggregate depth of some 11 million metres. Drilling in Canada has been mainly in the Western Sedimentary Basin, where oil reserves can be quickly developed and connected to markets. The drilling directed to natural gas has risen markedly over the past year. This is a result of western producers and marketers anticipating an increase in export volumes of gas being shipped to the United States. Statistics compiled near year-end indicated gas well completions were 77% above those for 1987. Exploratory operations in Canada's frontier regions have been reduced considerably. The Hibernia project located offshore of Newfoundland is however moving ahead as are two other major projects, the OSLO (Other Six Leases Operation) oil sands plant and the Husky heavy oil upgrader at Lloydminster.

EXPLORATION

Upstream, or exploration, indicators from January through November of 1988 registered an increase compared to the same period during 1987. The results of industry activity showed a strong level of operations during the first nine months of this year, but then declined sharply in the last quarter. This may have been the oil and gas industry's response to continuing low oil prices that cut its cash flow. Although the Alberta government and the Government of Canada made upward revisions to their incentive programs that would have normally been further reduced, the anticipated increase level of activity was not sustained in the last quarter. In Western Canada, revenues collected to date by the various provincial governments from Crown land sales fell by 14% to some $618 million from $718 million generated in the corresponding period of last year. The eleven-month average for active geophysical crews recorded a 16% gain, from 57 crews to 66 crews. The cumulative number of well licences issued in the western provinces rose by 28% to almost 8 400 licences compared to 6 540 permits issued at the same time last year. Well licence figures are useful in forecasting future well completions.

During 1988, the average monthly utilization rate of drilling rigs was about 49% or seven points above last year's average of 42%. For the past few years, the number of available rigs in the fleet had been close to 560 units and this may not change in the near future based upon current expectations. As an example of the sharp downturn in activity during the last months of 1988, the number of wells completed in November fell to 690 wells from 766 wells in October

---

R. Thomas is with the Energy Sector, Energy, Mines and Resources Canada. Telephone (613) 992-5466.

and down markedly from almost 1 150 completions in November of 1987. However, the higher level of drilling in the first three quarters of 1988 showed well completions to be almost 8 200 wells whereas 1987 resulted in close to 6 800 completions.

While there continued to be several oil and gas discoveries made throughout the provinces, perhaps the most noteworthy was announced in British Columbia. The province is predominantly gas-prone and more than five years have passed since its last discovery of crude oil. This was made at Desan, north of Boundary Lake in the northeast quadrant by Gulf Canada Resources Limited in partnership with AEC Oil and Gas Company Ltd. (Alberta Energy Company Ltd.) in February, 1983. The latest oil discovery had been made in August, 1987 and announced in November, 1988 at Brassey located in the Deep Basin gas play. The operator is Canadian Hunter Exploration Ltd. (CanHunter) and its partner in the field is BP America Inc. a subsidiary of The British Petroleum Company p.l.c. CanHunter was drilling for natural gas but a "blowout" determined the presence of large quantities of crude oil. Through the subsequent drilling of 13 wells in the area, nine have resulted in oil shows while the remaining four were dry. The nearly 30 km^2 Brassey field is located about 32 km southwest of Dawson Creek and at the northern tip of the Deep Basin. CanHunter anticipates the field to contain some 3 million m^3 (20 million barrels) of light (57° API) crude in the Triassic Charlie Lake formation at a depth of 3 000 m. The Brassey oil play is now the farthest south, and deepest, of any oil pool in the province.

RESERVES

For the first time since 1980, Canada's remaining reserves of total liquid hydrocarbons (crude oil, natural gas and natural gas liquids) have declined. Based upon the total volumes produced during the year, operators were successful in replacing only 72% as gross additions. In past years the replacement rate, or gross additions/production, was normally above 100% and in some years the rate exceeded 200%. The statistics, published annually by the Canadian Petroleum Association (CPA), showed the largest decrease in year-end reserves occurred in natural gas. In 1984, natural gas production had increased by almost 30% over the previous year and had since then remained constant. The volume of gross additions during 1984 had also increased by more than 200%, but then fell significantly and continued to decline in the following years. By 1987, the industry had only replaced 34% of its production in that year. Reserves of crude oil dipped marginally (94% replacement) and natural gas liquids showed a slight increase, with a replacement rate exceeding 160%.

According to CPA's reserves data, the remaining established reserves of crude oil and equivalent for total Canada at year-end 1987 stood at some 1 078 million m^3. This volume was down slightly from 1 084 million m^3 recorded in the previous year. In the conventional regions, crude oil reserves declined by some 3 million m^3, from 769 million m^3 to 766 million m^3. The frontier areas (north of 60° and eastcoast offshore) recorded a decrease of 1 million m^3, to some 174 million m^3. The volumes of pentanes plus in the conventional and frontier areas fell by almost 2 million m^3, to 138 million m^3. Oil production in the frontiers continues to come mainly from Norman Wells (Northwest Territories) with smaller additional volumes from the Bent Horn field in the Arctic Islands by Panarctic Oils Ltd.

Canada's remaining established reserves of marketable natural gas fell by almost 53 billion m^3 during the year, primarily due to the reduced volume of gross additions. The gas reserves at year-end amounted to 2 693 billion m^3, down from 2 745 billion m^3 estimated during 1986. The CPA revised downwards the volumes of natural gas in British Columbia by more than 22 billion m^3, leaving its remaining reserves at some 210 billion m^3. Alberta had its gas volumes reduced by some 22 billion m^3, because of the very low amount allowed for gross additions. The province contained about 1 728 billion m^3, or 64% of Canada's known reserves. In Saskatchewan, the increase in natural gas exploration during the past two years resulted in an increase in its reserves of some 500 million m^3 to almost 61 billion m^3. Reserve estimates in the frontier regions fell marginally, to 676 billion m^3. More than 400 billion m^3 are believed to remain in the Arctic Islands.

During the year, more than 11 million m^3 were added to the remaining reserves of natural gas liquids, raising the volume to almost 210 million m^3. The association continued to show ethane, propane and butane reserves for only the conventional regions while frontier gas reserves remain quite large.

PRODUCTION

In 1988, it was estimated that petroleum production (crude conventional and synthetic, pentanes plus/condensate, and natural gas liquids) increased by some 4% to an average of 317 000 m^3/d from 304 000 m^3/d. This volume is 10% higher than in 1986 and that for 1985. The largest increase in production was in that for conventional crude oil. Its portion had increased by some 10 000 m^3/d over the previous year to 215 000 m^3/d. The production of synthetic crude oil from the Syncrude Canada Ltd. and Suncor Inc. facilities rose marginally, from almost 29 000 m^3/d to 31 000 m^3/d. The volumes of pentanes plus/condensate remained about the same as last year at some 17 000 m^3/d while natural gas liquids rose slightly to average 43 000 m^3/d. Apparently, more of Canada's domestic crude had moved to eastern refineries, and particularily into the Montreal region as fewer imported quantities were required. Refiners conceded that the continuing fluctuations in oil prices were a major factor in inhibiting inventory replenishments. As domestic demand had grown, so had shipments of Canadian crude to the United States. It was estimated that producers had exported almost 111 000 m^3/d to the United States during the year. The increase in demand for conventional light and medium oils had resulted in producers withdrawing close to 3 500 m^3/d from existing inventories. On the other hand, producers of bitumen and heavy oil were able to increase their shipments to fulfill requirements regarding paving needs before the winter months. In the Northwest Territories, production from Norman Wells had averaged about 5 000 m^3/d from earlier introduction of enhanced oil recovery techniques.

It was estimated that total sales of marketable natural gas had increased by some 20 million m^3/d over 1987, due to larger volumes being shipped to the United States. Last year, domestic sales were about 130 million m^3/d and export volumes averaged almost 77 million m^3/d. In 1988, Canadian consumers used 145 million m^3/d while shipments to its southern neighbour rose to 92 million m^3/d compared to almost 77 million m^3/d in the previous year. Total sales for 1988 were around 227 million m^3/d, a 10% increase over the past year.

Of the three available markets for domestic gas (residential, industrial and commercial), the industrial consumer recorded the largest gain, from 72 million m^3/d in 1987 to some 75 million m^3/d in 1988. As in past years, the residential sector continued to require around 32 million m^3/d while commercial users maintained their historical level of 27 million m^3/d.

RESOURCES

The Geological Survey of Canada, through its Institute of Sedimentary and Petroleum Geology, assesses both provincial and frontier volumes of crude oil and natural gas that remain to be discovered. In the GSC's last published report, it was determined that there remained to be discovered some 570 million m^3 (median value) of light and medium crude oil in the Western Sedimentary Basin. Over one-half (315 million m^3) are believed to be contained in Devonian reservoirs. Throughout the rest of Canada, it is estimated that the reservoirs contain between 1 200 million m^3 (high confidence) and 7 700 million m^3 (speculative) of crude oil. The total potential for natural gas resources ranges from 4 000 billion m^3 to over 18 000 billion m^3, with an average expectation near 9 500 billion m^3.

OIL SANDS PROJECTS

Oil sands projects fall under two categories: surface mining projects or in situ bitumen projects.

(a) Surface Mining Projects

The surface mining of bitumen from oil sands deposits requires stripping the surface burden above the bitumen-bearing deposits. Therefore, this technology has a depth constraint for surface overburden beyond which the operation becomes uneconomical. The maximum depth of economic overburden removal is approximately 75 m. This means that less than 10% of only the Athabasca oil sands deposits are suitable for the application of this technology. The two existing surface mining projects in the Athabasca oil sands deposits are as follows:

(i) Syncrude Canada Ltd.

Syncrude continued to produce an average of some 20 000 m^3/d during the year from its licenced reserves. It is still working on the $1.2 billion expansion that was started in 1988 which will raise the plant output to an anticipated 25 000 m^3/d. The proponents were studying the possibility of an expansion to the existing facility (that would add an additional 12 000 m^3/d by mid-1990) but had later decided upon the construction of a new plant. The new project, called OSLO for "Other Six Leases Operation", will consist of the six leases owned by six of the eight operators and will be built across the Athabasca River from the existing facility at an estimated cost of about $4.0 billion. The federal government has accepted to extend fiscal assistance to the project and a feasibility study is now under way to determine its viability by 1991.

(ii) Suncor Inc.

The Suncor plant, while being the first to operate in Canada, is the next largest facility to Syncrude's in the Athabasca deposit. The company had announced that it was planning to spend $150 million to upgrade the plant capacity by 1 600 m^3/d, and further increasing to almost 11 000 m^3/d by the the mid-1990s. While the expansion is now partially completed, Suncor has announced that further work on this project must wait for a sustained increase in oil prices.

(b) In Situ Bitumen Projects

The use of "in situ" techniques is needed when oil sands deposits are too deep to be developed by surface mining methods. In situ operations utilize conventional vertical or slant wells for steam injection, necessary to heat the formation and lower the oil's viscosity, and subsequently placed on production to pump the bitumen to the surface. This type of operation, referred to as "Huff and Puff", continues through several such cycles to the economic limit for the well. This technique has been used in the Cold Lake and Peace River deposits of northern Alberta. There are presently three commercial projects that produce about 85% of total Canadian bitumen, and they are:

(i) Esso Cold Lake

Totally owned and operated by Esso Resources Canada Limited, this project produced an average of 12 000 m^3/d. Esso completed the fourth construction stage (phase 7 and 8) at the plant but will not conduct further steam injection until oil prices rise. The planned construction of the fifth stage (phases 9 and 10) have now been deferred.

(ii) BP/Petro-Canada Wolf Lake

BP Canada Inc. and Petro-Canada are equal partners in the project, located in the Cold Lake deposit, with BP acting as the operator. Plant production had been about 1 300 m^3/d, but both companies recently completed the expansion construction that would increase daily production to some 3 600 m^3. BP has now delayed steam injection until there is a stabilized increase in oil prices.

(iii) Shell Peace River

Shell Canada Limited had suspended an expansion program that would have increased production to 6 400 m^3/d from its current output of 1 600 m^3/d.

There are several other "pilot", or experimental projects that are in operation in the Cold Lake region. The companies operating these facilities are Amoco Canada Petroleum Company Ltd., Encor Energy Corporation Inc., Suncor Inc., and Westmin Resources Limited. These firms were considering making their projects "commercial" by expanding the facilities to 4 000-5 000 m^3/d but again these projects will be similarily affected as those mentioned above.

OUTLOOK

Projected well completions for 1988 were surpassed because of government incentives and anticipated higher oil and gas prices and exports so that the petroleum industry in Canada performed better than in 1987. For next year, several oil companies and trade associations have predicted that exploration and development activity levels will be lower than those for 1988. The CPA anticipates that operators will complete some 6 000 wells during the year, a return to 1986 levels. However, the increase in the drilling of gas wells will continue through the year as Western Canadian producers fulfill higher anticipated export sales. The natural gas industry has earmarked almost $200 million for the construction of several new small gas plants and expansion facilities, an increase over 1987 of about 46%. The further development of some oil sands projects and planned expansions to existing facilities has been deferred until oil prices are higher.

Figure 1

CANADA'S PETROLEUM REGIONS

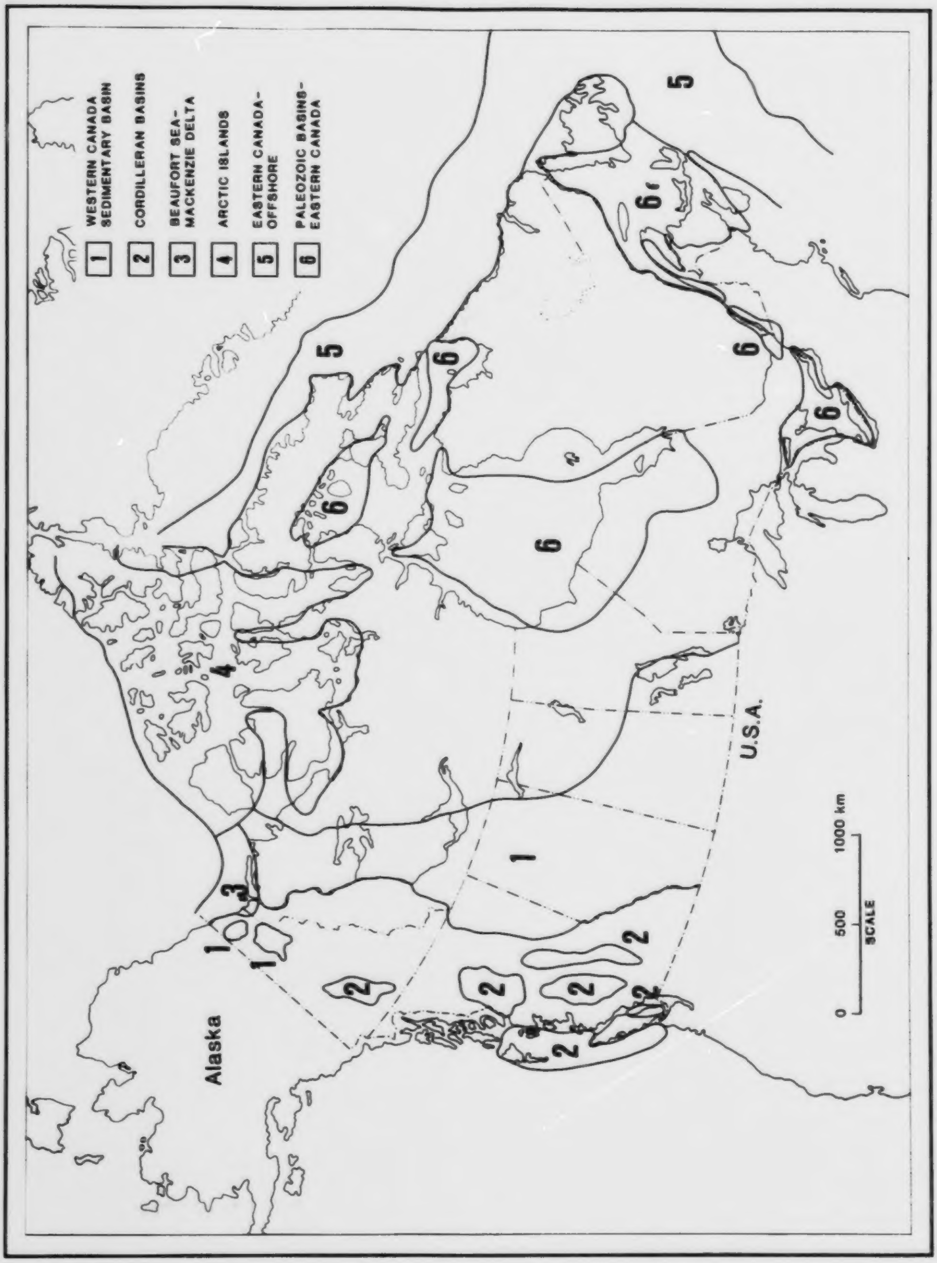
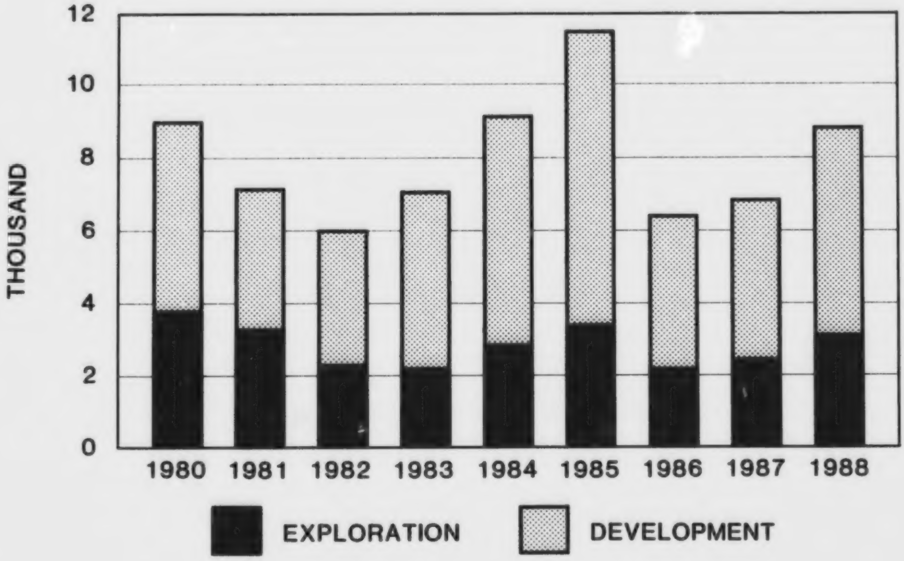

1 WESTERN CANADA SEDIMENTARY BASIN
2 CORDILLERAN BASINS
3 BEAUFORT SEA-MACKENZIE DELTA
4 ARCTIC ISLANDS
5 EASTERN CANADA-OFFSHORE
6 PALEOZOIC BASINS-EASTERN CANADA
Alaska
U.S.A.
1
1
1
2
2
2
2
2
2
3
4
5
5
6
6
6
6
6
6
0
500
1000 km
SCALE

Figure 2

WELL COMPLETIONS IN CANADA



Gold

D. LAW-WEST

Gold prices trended downward through 1988, from US$480 per oz. at the beginning of the year to just over $400 at year end. This was attributed to a variety of factors including the weakening U.S. dollar, rising interest rates, inflationary concerns, and the number of new mining projects under development worldwide, some of which are financed through gold loans. However, the 1988 average was only $10/oz. below the 1987 average, of $US447.

There were 66 primary gold mines in Canada at the end of 1988, which accounted for about 80% of the total 127.8 t of gold produced during the year. Proven and probable reserves at Canadian operating gold mines, at mines committed for production and in tailings recovery projects increased by 15% to 1 700 t.

SUPPLY: CANADIAN DEVELOPMENTS

Canadian operating gold mines are listed in the table which accompanies the map found in the review. Operating information for these mines may be found in the table of Nonferrous and Precious Metals Operations which follows the final commodity chapter of the Yearbook.

British Columbia: The grades and reserves at Corona Corporation's Nickel Plate mine have been downgraded to 9.1 Mt at 2.48 g/t of gold, compared with the original 9.9 Mt at 3.75 g/t. Higher stripping ratios and the lower head grade has resulted in average operating costs of US$335/oz.

On November 7, 1988, TOTAL Energold Corporation, formerly Getty Resources Limited, suspended operations at the Erickson gold mine near Cassiar due to exhaustion of reserves. An underground exploration program over the next 18 months is hoped to outline sufficient reserves to reopen the mine.

Houston Metals Corporation announced the discovery of additional ore at the Silver Queen mine which is under development near Houston. Current reserves are estimated at 1.73 Mt grading 2.7 g/t gold, 328 g/t silver and 6.2% zinc with associated copper and lead values. A feasibility study is being conducted by Cominco Engineering Services Ltd. The operation would produce: a copper-silver-lead concentrate with high gold and silver content, a clean zinc concentrate with silver values, and gold-silver bullion.

Following its official opening on August 17, 1988, Skyline Explorations Ltd. experienced initial start-up problems at its Johnny Mountain mine. The company modified the mill process by removing the cyanide circuit and recovering gold as a gravity concentrate. As well, the mining method has been changed in order to reduce dilution. Metal production increased significantly in November and December when mill throughput averaged 227 t/d and gold recovery averaged 77%.

The Snip deposit of Cominco Ltd. and Delaware Resources Corp. is considered to be one of Canada's better gold projects. Total reserves outlined to date are 1.2 Mt grading 19.8 g/t. Preliminary studies indicate that the deposit could support a 300 t/d milling operation.

Cheni Gold Mines Inc. expects to begin production in the Toodoggone region during the first quarter of 1989. The project may experience some cost overrun due to a switch in mining methods from shrinkage to blast hole stoping, entailing higher development costs.

Yukon and Northwest Territories: Belmoral Mines Ltd. agreed to purchase the Ketza River mine in the Yukon from joint venture partners Canamax Resources Inc. and Pacific Trans-Ocean Resources Ltd. The purchase price involves C$3 million plus

---

D. Law-West is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 992-4327.

1.25 million of Belmoral's common shares as well as 7 million share purchase warrants exercisable over the next two years at $2.25 per share. In addition, Belmoral has taken over Pacific Trans-Ocean. The mine has had trouble from the start of production when it was discovered that ore reserves were significantly lower than initially estimated. Actual ore reserves stood at some 250 000 t grading 10.8 g/t compared to the expected 460 000 t grading 12.7 g/t. Current reserves are expected to run out in 1992, but with substantial land holdings nearby there is good potential for new reserves being discovered. Some 530 000 t of sulphide ore grading 8.8 g/t are already known.

AGIP Resources Ltd. (67%) and TOTAL Energold (33%) closed the Mt. Skukum gold operation located south of Whitehorse. The drill indicated reserves calculated from the surface drilling program were not borne out in the underground development stage. This resulted in an uneconomic operation, but additional underground exploration work will be carried out. In the meantime, AGIP has negotiated a three year lease of the mill facilities to Skukum Gold Inc. and Omni Resources Inc.

Since the Ptarmigan mine near Yellowknife began commercial production in April 1988, the mine has produced 260 kg of gold from 20 350 t of ore averaging 11.6 g/t. Treminco Resources Ltd. expects ultimately to produce 780 kg/y from the Tom and Ptarmigan mines and its own 200 t/d mill. Currently the company is custom milling its ore at Giant Yellowknife.

Reported placer production in the Yukon in 1988 was expected to be around 4 500 kg.

Saskatchewan: International Mahogany Corp. and its 30% partner and operator, Corona Corporation, opened the Jolu mine in November 1988. The company expects to produce 1 870 kg/y from the 400 t/d operation at a cost of $160/oz. Reserves for the mine are 627 000 t grading 10.7 g/t.

Claude Resources Inc. has received a prefeasibility study on the Seabee deposit in northern Saskatchewan. Undiluted proven and probable reserves have been estimated at 645 000 t grading 10.3 g/t plus an additional 367 000 t at 10.3 g/t of possible reserves. A recently conducted metallurgical test indicated that a least 31% of the gold can be recovered in a gravity concentrate. The company expects that output will be about 1 500 kg/y when production begins.

There are several other projects under way that could add significantly to Saskatchewan's gold production. Vista Mines Inc. announced the pouring of a 13 kg dore bar from a 10 000 t bulk sample from the AJB and PLG zones at its Bootleg Lake project. Vista also announced underground exploration and development at the Rio project, and its joint venture partners are spending some $6 million on underground exploration at the Fork Lakes property. Cameco - a Canadian Mining & Energy Corporation, was formed late in 1988 through the merger of Saskatchewan Mining Development Corporation (SMDC) and Eldorado Nuclear Limited and it assumed the former's interests in the Star Lake gold mine and the Fork Lakes gold project. The Star Lake mine exhausted its ore reserves, but the mill will continue to operate from surface stockpiles until April 1989.

Manitoba: LynnGold Resources Inc. (formerly SherrGold Inc.) reduced operating costs at the MacLellan gold mine to US$327/oz. from $380. Increased throughput at the mill resulted in gold production increasing from 325 kg in the first quarter to 490 kg in the second quarter of 1988.

Granges Exploration Ltd. announced a three week shut down of its operations at Tartan Lake after technical difficulties in the mill. Granges operates the mine as a joint venture with Abermin Corporation. A recent study has concluded that mine grade will be somewhat lower than originally expected and as a result the mine may be operated at a significantly reduced rate.

Ontario: International Corona Resources Ltd. announced a merger with four of its operating companies - Royex Gold Mining Corporation, Lacana Mining Corporation, Mascot Gold Mines Limited and Galveston Resources Ltd. - to form Corona Corporation.

Canamax Resources expects the Kremzar mine, 20 miles northeast of Wawa in northern Ontario, to be its main gold producer in the future. The mine, which officially opened on October 4, 1988, is expected to produce about 1000 kg/y of gold at an average cost of C$295/oz.

ERG Resources Inc. (owned 61.6% by Pamour Inc., which is in turn owned 67.5% by Giant Resources Limited of Australia) opened its $78 million Schumacher tailings project. In the first full year of production in 1989, gold output is expected to total 3420 kg. The Schumacher mill was built to process over 200 Mt of tailings that are located in the Timmins area, and which are sufficient to support production for 17 years. This is the second such project for the Giant Yellowknife group (owned 41.8% by Pamour). The first, located at the Giant Yellowknife mine in the Northwest Territories was commissioned in May 1988.

Lac Minerals Ltd. has announced a $20 million plan to expand the Macassa mill from 450 to 1250 t/d. The mill feed will come 500 t/d from the Macassa mine and 750 t/d from the Lake Shore tailing recovery project.

On August 9, 1988, the Holt-McDermott mine was officially opened by American Barrick Resources Corporation. When full capacity is reached the $78 million mine will operate at 1360 t/d with annual gold production of 2490 kg costing some US$220/oz. The mine life based on current reserves is about seven years.

Muscocho Explorations Ltd. and McNellen Resources, Inc. have opened the Magino mine near Wawa in northern Ontario. The mill will operate at 360 t/d. Proven and probable ore reserves are 1.75 Mt grading 8.6 g/t, to a depth of 150 m.

Noramco Mining Corporation closed its Golden Rose mine in northern Ontario and laid off 100 employees. The company is focusing its efforts on gaining access to higher grade material. If the program is successful, the operation could restart at a rate of 63 500 t/y grading 10.3 g/t. The mine had officially been opened on October 7, 1987.

Bond International Gold, Inc. announced that the first gold had been poured at the Golden Patricia mine which it acquired from St. Joe Gold Corporation. The underground mine and mill complex is operating at full design capacity of 250 t/d, and is expected to annually produce 1400 kg of gold. Current reserves are 368 000 t grading 230.5 g/t.

Eastmaque Gold Mines Ltd. reported that it is recovering 60% of the gold from the old tailings in a concentrate grading 2 oz./t. The concentrate is shipped to Noranda's Horne smelter and the company expects to recover 750 kg/y.

Canamax purchased a 50% interest in the Bell Creek gold mine of joint venture partner Pamorex Minerals Inc. for $16.5 million plus undisclosed net smelter royalties.

There are several serious projects under development in northern Ontario. In the Musselwhite area, several companies have outlined reserves of over 6 Mt grading 6.3 g/t and production could begin by the early 1990s. Citadel Gold Mines Inc. is planning a $15 million underground test of the Surluga deposit, where there is a 750 t/d mill on site which can be refurbished to 500 t/d for about $2.2 million.

Quebec: Since opening in 1980, the Doyon mine has become the province's largest gold producer, accounting for 25% of output. Production increased to 8090 kg in 1988 from 7710 kg in 1987. The operation is a joint venture between Cambior inc. and Lac Minerals Ltd. The partners originally invested some $7 million to bring the first open pit into production. More recently they have invested an additional $67 million in underground preproduction development and plan to spend an additional $15.5 million to boost underground production to 3000 t/d in order to replace the open pits which will be exhausted in 1989. There has also been a $21 million expansion of the mill.

The $73 million Bousquet 2 mine, located on the eastern boundary of the Bousquet 1 property, is under development and should be in production by the end of 1989 and reach full production of 4300 kg/y by 1991. Lac Minerals, owner of both properties has not yet made a decision on where the ore will be milled but one possibility is the East Malartic mill which has had excess capacity since the Doyon mill was expanded.

Cambior inc. has announced plans to develop the Pascalis mine. The $15.5 million program includes a milling and concentrating facility with final gold recovery carried out at the nearby Vezina mill. The open pit operation will mine 354 000 t/y and produce 1100 kg of gold at an average cost of C$260/oz. Proven and probable reserves are 1.2 Mt grading 3.4 g/t.

Joint venture partners Rouyn Mining Resources Inc. and Lac Minerals have opened the Francoeur mine. Production for 1988 is expected to be 570 kg, increasing to 1370 kg in 1989 and 1710 kg in 1990. The partners are considering the feasibility of a 1200 t/d mill. Reserves on the property total 3 Mt grading 6.2 g/t of gold.

Campbell Resources Inc. increased gold production at the Joe Mann mine near Chibougamau during the first nine months of 1988 from 1180 kg to over 1400 kg. Fourth quarter production remained steady at 435 kg for a total output of nearly 1870 kg for the year. An $18.2 million expansion at the mine will increase annual production by 1100 kg to 3100 kg by 1992.

At the Astoria joint venture project of Yorbeau Resources Inc. (50%) and Belmoral Mines Ltd. (50%), the $10 million shaft-sinking program, funded by Belmoral to earn its interest, has been slowed due to poor ground conditions. The target depth of 1680 ft. will gain access to the high grade AW ore zone. Total reserves on the property are 1.4 Mt grading 5.1 g/t. The ore will be processed at Belmoral's mill.

Tundra Gold Mines Limited continued its extensive exploration program on the Lamaque mine which closed in 1985. Tundra has already spent some $9 million on the property and is now preparing to sink a 300 m shaft to conduct 4000 m of detail drilling on the No. 4 plug. The 1800 t/d mill requires some $4.5 million to be refurbished. The current reserves of 1.2 Mt grading 4.8 g/t of gold are sufficient to justify reopening the mine and a decision is expected soon. Tundra has an option until September 30, 1989 to purchase the 50% share of the Lamaque mine currently held by Teck Corporation.

Augmitto Explorations Limited arranged financing for the preproduction stage of its Beauchastel gold project near Rouyn and production is expected to begin in early 1989.

Atlantic Canada: Northumberland Mines Limited and NovaGold Resources Incorporated merged their holdings and will together develop the Murray Brook mine in New Brunswick. The 1000 t/d mine was on-stream at the end of 1988. Annual output of 3400 kg of gold and 7000 kg of silver is expected for the five year life of the operation.

Westminer Canada Limited, the new owners of Seabright Resources Inc.'s Nova Scotia operations, announced the closure of the Caribou mine. The closure, which will affect about 70 employees, is part of the company's efforts to make the Nova Scotian operations more competitive.

Results of a bulk sample test at the Tangier property were positive and Coxheath Gold Holdings Limited expects to produce 875 kg/y from a 200 t/d operation. Operating costs are projected at US$220/oz. In the past two years the company spent $15 million on exploration.

Hope Brook Gold Inc. commissioned its 3000 t/d mill in southwestern Newfoundland in September. The heap leach operation will continue until mid-1989. Hope Brook's underground development reached the 2095 m level and the first ore was produced in December.

Dolphin Explorations Ltd. plans to spend $3 million to further explore its Cape Ray property. Corona Corporation will supply some of the money to be used for 10 000 m of surface drilling and the construction of a road to the property. Reserves to date are estimated at 1.03 Mt grading 9.6 g/t.

To date, Noranda Exploration Company, Limited has outlined 4 Mt grading 6.62% zinc, 3.53% copper, 1.05% lead, 67.39 g/t silver and 1.02 g/t gold at the Duck Pond property.

SUPPLY: WORLD DEVELOPMENTS

United States: Gold production is estimated to have increased substantially in 1988 to over 202 t from just under 155 t in 1987. Much of the increase came from new operations starting up in the western states. Some of the more important developments are reviewed below.

The Montana Tunnels project began production in April and is expected to have produced about 2640 kg of gold in 1988. Gold Fields Mining Corporation started commercial production at its $80 million Chimney Creek property in Nevada late in 1987 using both heap leaching and standard milling. Reserves are 26.9 Mt at 2.1 g/t. The mine operates at 12 500 t/d and annual gold production is expected to be around 4666 kg/y over the 15 year life of the mine.

Corona Corporation opened the Santa Fe open pit gold mine near Hawthorne, Nevada. The US$10.5 million, 8000 t/d operation is expected to produce 1555 kg/y of gold. Proven reserves at the heap-leaching operation are 8.5 Mt grading 1.2 g/t and 9.9 g/t of silver. Cash operating costs are US$256/oz.

US Gold Corp. announced the first pour of gold at the White Pine operation, the company's third operation in Nevada. The output for 1988 was roughly 400 kg, but is expected to increase to 3700 kg in 1989. Operating costs at White Pine are US$210/oz.

Using US$71.3 million from a 4670 kg gold loan, First Miss Gold Inc. commenced development of the Getchell mine/mill near Winnemucca. Production is to begin in January 1989 and is expected to reach 5290 kg in 1990.

The Goldstrike deposit, being developed jointly by Newmont Mining Corporation and American Barrick Resources Corporation, will be mined by an open pit which will straddle the boundary between the two companies properties. The deposit contains about 26 Mt of reserves. In 1987, the property produced 1245 kg at a cost of US$311/oz., but once production reaches the design of 10 000 t/d, costs will drop significantly. American Barrick announced that it had arranged a 32 660 kg gold loan to finance its portion of the development costs.

AMAX Inc. announced plans to expand annual gold production from the Sleeper mine by 1245 kg to 7775 kg in 1989.

FMC Gold Corp. (30%) and Freeport-McMoRan Inc. (70%) announced plans to expand production at the Jerritt Canyon mine by 20%. Production by mid-1989 should surpass 9330 kg/y.

Echo Bay Mines Ltd. plans to produce 7000 kg of gold and 84 t of silver from the McCoy/Cove property in Nevada during 1989. In 1988 production was about 3110 kg of gold and 22.2 t of silver. In 1990, production of gold and silver is expected to be 10 265 kg and 202 t, respectively.

Galactic Resources Ltd. started initial gold production at the Ridgeway mine in South Carolina in December 1988. Commercial production at the US$81 million operation should begin in the first quarter of 1989 at an annual rate of 4200 kg.

Echo Bay, Crown Resource Corp. and Gold Texas Resources Ltd. have announced development of the Kettle Creek property in Washington state with production to start by early 1990. The capital cost of US$47 million will be sufficient to develop a 1400 t/d operation capable of producing 3420 kg/y at a cost of $175/oz. In the first two years, production will be 2640 kg/y at a cost of $196/oz. Reserves are 3.9 Mt at 5.6 g/t.

Australasia: In Papua New Guinea a strike at the Ok Tedi mine started on September 21, 1988 over new housing allowances and job classifications. An earlier thirteen day strike in August led to the premature end of gold mining at the operation. In the first six months of 1988 gold production totalled 10 588 kg. The company is owned 20% by the Papua New Guinea government, 30% by The Broken Hill Proprietary Company Limited, 30% by Amoco Corporation, 7.5% each by Degussa AG and Metallgesellschaft AG and 5% by West German Development Co.

Placer Pacific Pty. Ltd. received the go ahead to mine the Misima deposit for 21 years. Construction began in January 1988 with completion expected by July 1, 1989. The Papua New Guinea government has taken a 20% interest in the operation. Reserves at the project are estimated at 56 Mt grading 1.38 g/t of gold and 21.0 g/t of silver. The deeply oxidized deposit will be mined at a rate of 15 000 t/d giving a current mine life of 10 years. By 1991, annual production is expected to be 200 000 oz. of gold and 2.1 M oz. of silver. Capital cost of the project is estimated at A$286 million. Placer Pacific is owned 75.8% by Placer Dome Inc. of Canada.

The feasibility study for the Porgera mine was presented to the Papua New Guinea government for approval and a decision is expected in 1989.

The joint venture partners MIM Holdings Limited, Placer Pacific and Renison Goldfields Consolidated Ltd., each hold 33.3%. Recoverable open pit reserves outlined to date are 50.6 Mt grading 4.1 g/t. Underground reserves are estimated at 3.6 Mt grading 28.7 g/t. The project is designed to produce 8000 t/d of ore. Capital costs are planned at US$750 million and the mine life should be 19 years.

The Rimu alluvial gold project on the South Island of New Zealand went into production in June 1988 at an annual rate of 311 kg/y. L&M Mining Ltd. will operate the project during its four year life but other areas for alluvial operation have been delineated.

The Martha Hill mine located near Waihi on the North Island is being reopened. First operated in the late 1800s the mine produced some 370 t before it was closed down in 1952. Reopened by Waihi Gold Mining Ltd., a joint venture company owned by AMAX Inc. (28.35%), Goodman Fielder Wattie (15.46%), Mineral Resources Ltd. (27.84%) and Australian Consolidated Minerals Ltd. (27.84%), the new operation will produce about 1560 kg/y of gold and 9330 kg/y of silver.

The Golden Cross mine located near Martha Hill is expected to produce about 2500 kg/y when production begins in 1990. The McRae mine located on the South Island is also expected to start up in 1990 and will produce 1990 kg/y for at least 10 years. Dredging on the Grey River on the South Island could produce 620-780 kg/y using a refurbished dredge.

The Australian Bureau of Agriculture and Resource Economics forecast that Australian gold production will rise to 160 t in the year ending June 1989, up from the 127 t in 1987/88.

A program at the Mount Gibson mine to increase mining and processing capacity to 1.1 Mt/y, was completed. Production started in 1986 with a design capacity of 525 000 t but throughput reached 700 000 t in 1987 with production of 2210 kg of gold.

An expansion program is currently under way that will make the Boddington mine the largest gold producer in Australia. Reynolds announced a doubling of mining capacity to 6 Mt/y by the middle of 1989 at a cost of US$30 million. Reserves at the operation have increased from 45 Mt to 60 Mt.

Placer Pacific and joint venture partner Australian Consolidated Minerals Ltd. expect that the Big Bell gold mine located in Western Australia will begin production early in 1989. Gold output is expected to be about 5000 kg in its first year of production.

Australian gold production is expected to surge during the next two years. The industry loses its tax free status effective January 1, 1991. Industry analysts expect that there will be a negative impact on gold development, due to the longer capital repayment time.

Rest of World: In Brazil, Companhia Vale do Rio Doce (CVRD) is planning to begin gold production from the Igarape Bahia mine in the Carajas region by mid-1989. The mine has reserves of 65 t of gold. Initial production will be 100 kg/y rising to 2000 kg by 1991. This is part of the company's $250 million plan to become a major gold producer.

The Fazenda Brasileiro mine, located in Bahia state came on-stream in September 1988. It is expected to produce 2000 kg/y of gold initially but then to increase its output to 6 000 kg within three years.

The Morro do Ouro gold mine near Paracatu in northwest Minas Gerais was opened by Rio Paracatu Mineracao S.A., a joint venture company of RTZ Mineracao Ltda. (51%) and Autram Mineracao e Participacoes S.A.(49%), in December 1987. Annual gold production is 3000 kg.

The Brazilian government passed a law that restricted majority ownership of Brazilian resources to domestic companies. It gave foreign companies a five year period to find major Brazilian owners for their companies.

The Indian government started to allow the import of gold for export-orientated jewellery production. The Minerals & Metals Trading Corp. of India Ltd. (MMTC) made arrangements with the Union Bank of Switzerland to take delivery of gold and then pay for it when the jewellery is exported.

India is thought to have the largest gold hoard in the world, estimated at over 7000 t. Nearly all of the gold has been smuggled into the country. In 1963, the government imposed the Gold Control Act in order to regulate the use of gold.

India has been encouraging gold exploration in order to replace declining reserves at existing mines. Exploration targets include the Chicargunta field near the operating Kolar mine which produced 618.9 kg in 1986/87 and 521.6 kg in the first ten months of 1987/88. In its 100 year operating history, the Kolar mine has produced 800 t of gold.

Philippine gold production in the first six months of 1988 totalled 16 503 kg, up 15% from the 14 347 kg produced in 1987.

An open pit gold mine is being developed 500 km south of Addis Ababa, Ethiopia. The mine, expected to begin production in 1989, will produce 32 t/y of gold. The construction is being financed by a $9 million loan from the EEC and the South African Development Bank.

The International Finance Corporation, the World Bank private sector lending arm, has provided a US$7.5 million credit for an alluvial gold mine operation in Guinea. The $28.7 million project is a joint venture between Chevaning Mining Company and the Republic of Guinea. The project will produce 80 000 oz./y during its nine year life.

Gold production has begun at the Sigiri-Koron mine in upper Guinea. The project is operated by St. Aurifere De Guinee, a company formed by the Guinean government, Union Minière SA of Belgium and Pancontinental Mining Ltd. of Australia. While reserves are not yet public, annual gold production is estimated at 90 000 oz.

Gold production from the world's largest producer, South Africa, increased to 619 t in 1988, from 605 t in 1987.

Japan introduced a tax on interest payments made on savings accounts, effective April 1, 1989. Profits of under 500 000 yen/y on gold trading remain untaxed. This new system could affect the small gold purchaser. There is an estimated 300 000 billion yen in savings accounts in Japan that will be subject to the 20% savings tax and experts predict that some of this money will be invested on gold. Japanese imports of gold should increase as a result.

Taiwan imported 333.82 t of gold during the first eleven months of 1988 compared to 55.71 t in the same period of 1987. This volume includes 289.04 t of gold bars compared to 23.9 t in 1987 and 2.56 t of coins compared with 1.54 t in 1987. This rise can be attributed to government purchases of gold in an effort to reduce the country's trade surpluses with its major trading partners.

CONSUMPTION AND USES

The industrial consumption of gold, sometimes referred to as fabrication demand, includes gold consumed in jewellery, electronics, dentistry and both fake and official coins, even though the latter type of coin is often used for investment purposes. The graph at the end of this section gives some historic perspective to world gold consumption by these industries.

In Canada the largest use of gold is for official coins. The Royal Canadian Mint produces two official coins that contain gold, a numismatic gold coin containing a quarter ounce of gold with a face value of $100 and the Gold Maple Leaf bullion coin family. Prior to 1987 the numismatic coin contained half an ounce of gold but the price of gold had been adversely affecting its sales.

The world renowned Gold Maple Leaf bullion coin with its very high purity has continued as one of the most popular coins of its type. International sales totalled 37.5 t in 1988, down from 44.3 t in the previous year. The drop in sales reflects the general downturn in gold markets.

The Maple Leaf coin plays an important role in the Canadian gold industry. Since its introduction in 1979 the program has consumed some 375 t of gold representing 50% of total Canadian production.

The domestic carat jewellery industry has two main components, smaller manufacturers producing jewellery pieces in Canada and larger sales companies importing stock jewellery pieces for direct sales. On average Canadian gold consumption for jewellery is about 10 t/y.

Most other gold products used in Canada are imported either in end-use form or in semi-manufactured alloy form. Canadian consumption of gold in electronics, dentistry and other industrial uses totalled just above one t in 1987 and was not expected to show any dramatic change for 1988.

MARKETS, PRICES AND STOCKS

The investment demand for gold is generally held to be the mechanism that balances gold supply and demand.

Traditionally gold was supplied to the market from two main sources, new mine production and scrap recycling. During the past few years increasing amounts of gold have been introduced to international markets in the form of gold loans. Because of the nature of gold loan agreements between the lending banks and the borrowing producers, an accurate figure for the total amount of borrowed gold is not available. While the market has been able to absorb the additional gold, the sale of borrowed gold to raise funds for corporate purposes - typically the development of new gold production capacity - may have both short term and longer term depressing effects on gold prices.

Prices started the year at a peak near US$480 but proceeded to decline, tested the $380 mark before recovering to just over $400 at year end. Prices averaged $436, about $10 below 1987. Graph No. 1 shows a plot of the daily price quoted by the London Bullion Market Association.

Gold stocks are estimated at just over 100 000 t, only slightly less than the estimated total amount of 105 000-110 000 t produced since biblical times. Thus, while new gold production is increasing, the addition to stocks from this source is slightly over 1%/y. Consequently the relationship between new production and prices is not necessarily as direct as for base metals.

In November 1987, the London Bullion Market Association (LBMA) was formed from its predecessors, the London Gold Market and the London Silver Market. The new association was formed to meet the requirements brought about by the new Financial Services Act which came into effect April 28, 1988. The LBMA has admitted 13 market makers and 40 ordinary members. There are five new members that were not members of the LGM, including the Bank of China, Barclays PLC and Brinks-Mat Ltd.

The London market provides two price fixes one at 10:30 a.m. and the other at 3:00 p.m. local time. The fixes occur at a price when buy and sell orders by members of the LBMA are balanced.

OUTLOOK

Canadian gold production is expected to continue growing until at least the mid-1990s. Within the next few years production will surpass the record of 166 t of gold recorded in the early 1940s. Eventually annual output could reach 190 t. World gold production will also continue to increase as more developing countries increase exploration programs. Other established gold producers such as Australia, Papua New Guinea, United States and South Africa continue to increase production and there is some concern that with large additions to new gold production, prices could be adversely affected.

Gold analysts' explanations of gold's price performance tend to differ quite widely. Investment demand for gold, which contributes much to balancing supply and demand, responds to the attractiveness of other investment vehicles. Interest rates tend to inversely affect gold prices, fears of inflation often drive the price of gold up and to a lesser extent so do political tensions. So far, increased gold production and gold loans appear to have had a limited but indeterminate impact on prices, at least as denominated in U.S. dollars. However, should major gold hoarding countries such as Japan and Taiwan reduce their purchases during the current period of rising interest rates and increasing production, then strong downward pressure could see gold prices testing $350 or lower in 1989.

The longer term outlook for gold is, at best, difficult to forecast. The continued expansion of gold mine output should have a dampening effect on prices. However, this would require that only lower cost producers continued to open up. Many of the present and planned producers are coming on-stream by the use of gold loans. As these loans become more common they will be viewed as a new and permanent source of supply to the market, and as their volume increases so will the added downward pressure on gold prices.

There will likely be a limiting factor on these loans, as the price of gold drops the amount of gold required to borrow increases and will limit the amount of future production that a mining company will be willing to commit for repayment.

TABLE 1A. CANADA, GOLD PRODUCTION AND TRADE, 1985-87

	1985	1986	1987
		(grams)	
Production			
Newfoundland	-	-	x
Nova Scotia	-	-	x
New Brunswick	283 445	373 658	419 573
Quebec	30 103 798	28 341 749	29 543 289
Ontario	32 261 375	46 278 552	52 917 136
Manitoba	2 162 285	2 555 506	3 696 748
Saskatchewan	224 743	13 872	1 048 443
Alberta	27 460	36 178	43 292
British Columbia	6 720 050	9 248 766	11 223 704
Yukon	3 064 763	3 547 359	4 674 260
Northwest Territories	12 712 939	12 503 280	11 739 860
Total	87 560 858	102 898 920	115 817 580
Total Value (C$)	1 219 653 297	1 689 291 569	2 204 471 818

Exports	1985		1986		1987	
	(kilograms)	($000)	(kilograms)	($000)	(kilograms)	($000)
Gold in ores and concentrates						
Japan	5 257	56 798	5 959^r	76 158^r	6 237	92 891
West Germany	-	1	211	3 768	745	12 705
Belgium-Luxembourg	65	837	116	1 862	425	6 930
People's Republic of China	-	-	217^r	2 424^r	120	1 667
Sweden	73	703	94	1 056	46	956
United Kingdom	45	502	78	933	58	857
United States	187	2 534	232	3 572	40	607
Other countries	407	3 844	395^r	5 126^r	935	13 336
Total	6 034	65 219	7 302^r	94 899^r	8 606	129 949
Gold						
United States	99 260	1 391 786	152 357^r	2 568 435^r	45 169	863 102
Japan	5 313	73 817	5 521	88 564	14 315	284 205
Switzerland	164	2 213	1 037	16 509	1 227	23 999
Hong Kong	1 037	13 481	30	461	1 009	19 743
Italy	113	1 603	134	2 178	90	1 676
United Kingdom	6	73	46	819	53	924
Panama	1 754	24 754^r	553	8 629	41	753
Other countries	866^r	12 045^r	283^r	4 556^r	281	5 530
Total	108 513	1 519 774^r	159 961^r	2 690 152^r	62 185	1 199 931

TABLE 1A. (cont'd)

	1985		1986		1987	
	(kilograms)	($000)	(kilograms)	($000)	(kilograms)	($000)
Exports (cont'd)						
Gold alloys						
Belgium-Luxembourg	-	-	-	-	7 181	118 809
United States	1 962	22 573r	4 222	55 097	369	4 104
Trinidad-Tobago	178	1 293	26	265	18	133
Italy	1	13	7	126	-	-
West Germany	2 561	31 457r	1 038	14 226	-	-
Other countries	14	118r	255	3 551r	82	1 183
Total	4 716	55 454	5 548	73 264	7 650	124 229
Gold coin	..	783 908	..	647 414	..	658 831
Imports						
Gold in ores and concentrates						
Peru	108	1 310	166r	2 175r	365	6 220
Chile	-	-	-	-	263	4 993
Indonesia	-	-	-	-	228	4 368
United States	284	3 657	346r	4 965r	82	1 479
Italy	-	-	-	-	70	1 325
Other countries	83r	1 133r	198r	2 944r	53	836
Total	475	6 100	710	10 084r	1 061	19 221
Gold						
United States	69 202	967 535	66 032r	1 081 458r	22 313	415 218
Uruguay	-	-	276	4 696	4 687	86 327
Guyana	-	-	9	180	585	10 564
Switzerland	539	7 519	412	6 494	513	10 001
Chile	44	621	-	-	369	6 983
West Germany	377	5 293	100	1 596	18	297
Other countries	1	26	4	87r	944	18 448
Total	70 163	980 994	66 833r	1 094 512r	29 429	547 837
Gold alloys						
United States	17 441	211 415	45 562r	626 432r	24 687	389 057
Uruguay	-	-	-	-	1 723	33 217
Venezuela	-	-		-	1 578	24 865
Nicaragua	1 614	9 308	1 646	14 059	2 018	15 978
Mexico	22	288	-	-	191	3 686
Togo	-	-	-	-	130	1 353
Bolivia	-	-	-	-	60	886
Other countries	6 641r	73 089r	1 092r	19 209r	120	1 254
Total	25 718	294 099	48 300r	659 700r	30 507	470 295

Gold coin						
United States	..	5 662	..	37 764	..	20 899
Switzerland	..	1 663	..	555	..	2 538
Bahamas	-	-	-	-	..	749
Other	..	917	..	737	..	21
Total	..	8 242	..	39 055	..	24 207

Sources: Energy, Mines and Resources Canada; Statistics Canada.
r Revised; - Nil; .. Not applicable; x Confidential.
Note: Totals may not add due to rounding.

TABLE 1B. CANADA, GOLD PRODUCTION AND TRADE, 1988P

Item No.	1988P (grams)
Production (shipments)	
Newfoundland	x
Nova Scotia	x
New Brunswick	73 500
Quebec	32 485 000
Ontario	57 881 900
Manitoba	4 285 000
Saskatchewan	2 083 200
Alberta	20 400
British Columbia	13 036 100
Yukon	4 303 600
Northwest Territories	11 421 800
Total	127 842 500
Total Value (C$)	2 215 128 000

Item No.		1988P Jan.-Sept. (kilograms)	1988P Jan.-Sept. ($000)
Exports			
2603.00	Copper ores and concentrates		
2603.00.82	-----Gold content	7 479	58 053
2608.00	Zinc ores and concentrates		
2608.00.82	------Gold content	199	2 359
26.16	Precious metal ores and concentrates		
2616.10	-Silver ores and concentrates		
2616.10.82	------Gold content	486	9 435
71.08	Gold (including gold plated with platinum) unwrought or in semi-manufactured forms, or in powder form		
7108.11	--Powder		
	Belgium	20	300
	West Germany	4	72
	United States	1	15
	Total	25	387
7108.12	--Other unwrought forms		
	United States	31 321	534 722
	Japan	26 418	470 117
	Hong Kong	16 409	284 472
	Switzerland	14 675	257 858
	United Kingdom	1 934	32 337
	Singapore	1 500	26 630
	Taiwan	1 200	22 283
	West Germany	528	9 004
	People's Republic of China	451	7 928
	Poland	78	1 286
	Italy	69	1 183
	Other countries	202	1 932
	Total	94 785	1 649 752

TABLE 1B. (cont'd)

Item No.		1988P Jan.-Sept.	
		(kilograms)	($000)
Exports (cont'd)			
7108.13	--Other semi-manufactured forms		
	Japan	..	101 442
	Switzerland	..	88 968
	United States	..	77 990
	Hong Kong	..	76 671
	Belgium	..	59 956
	West Germany	..	39 420
	People's Republic of China	..	12 680
	Singapore	..	5 750
	Austria	..	2 667
	Taiwan	..	2 141
	Bahamas	..	1 990
	Costa Rica	..	1 304
	Other countries	..	643
	Total	..	471 622
Imports			
2603.00	Copper ores and concentrates		
2603.00.00.82	-----Gold content	372 067	6 460
2607.00	Lead ores and concentrates		
2607.00.00.82	-----Gold content	542 880	7 267
2608.00	Zinc ores and concentrates		
2608.00.82	------Gold content	39 248	491
26.16	Precious metal ores and concentrates		
2616.10	-Silver ores and concentrates		
2616.10.82	------Gold content	18 171	333
71.08	Gold (including gold plated with platinum) unwrought or in semi-manufactured forms, or in powder form		
7108.11	--Powder		
	United States	26 455	197
	United Kingdom	243	3
	Total	26 698	200
7108.12	--Other unwrought forms		
	United States	30 045 820	484 907
	Mexico	3 992 806	68 221
	Bolivia	1 154 014	18 565
	Venezuela	790 000	14 000
	Nicaragua	890 480	10 103
	Chile	500 024	7 201
	Guyana	183 631	3 267
	Switzerland	176 474	3 152
	Other countries	117 387	1 663
	Total	37 850 636	611 079
7108.13	--Other semi-manufactured forms		
	United States	503 611	1 950
	United Kingdom	119 883	1 904
	West Germany	65 084	850
	Italy	194	3
	Switzerland	116	1
	Total	688 888	4 708

Sources: Energy, Mines and Resources Canada; Statistics Canada.
P Preliminary; x Confidential; .. Not available or not applicable.

TABLE 2. CANADA, GOLD PRODUCTION BY SOURCE, 1970, 1975 AND 1980-88

	Auriferous Quartz Mines		Placer Operations		Base-Metal Ores		Total	
	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)
1970	58 592	78.2	229	0.3	16 095	21.5	74 915	100.0
1975	37 530	73.0	335	0.6	13 569	26.4	51 433	100.0
1980	31 929	63.1	2 060	4.0	16 632	32.9	50 620	100.0
1981	35 877	69.0	1 633	3.1	14 525	27.9	52 034	100.0
1982	47 866	74.0	2 477	3.8	14 393	22.2	64 735	100.0
1983	55 522	75.5	3 235	4.4	14 756	20.1	73 512	100.0
1984	62 554	75.0	3 393	4.1	17 499	20.9	83 446	100.0
1985	67 241	76.8	3 464	4.0	16 857	19.2	87 562	100.0
1986	83 197	80.9	2 802	2.7	16 900	16.4	102 899	100.0
1987	93 862	81.0	4 009	3.5	17 903	15.5	115 818	100.0
1988P	106 631	83.4	3 785	3.0	17 427	13.6	127 843	100.0

Sources: Statistics Canada; Energy, Mines and Resources Canada.
P Preliminary.

TABLE 3. CANADA, GOLD PRODUCTION, AVERAGE VALUE, AND PERCENT OF TOTAL MINERAL PRODUCTION

	Total Production	Total Value	Average Value[1]	Gold as a Percent of Total Mineral Production
	(kg)	(C$000)	(C$/g)	(%)
1970	74 915	88 057	1.18	1.5
1975	51 433	270 830	5.27	2.0
1980	50 620	1 165 416	23.02	3.7
1981	52 034	922 089	17.72	2.8
1982	64 735	968 012	14.95	2.9
1983	73 512	1 230 886	16.74	3.2
1984	83 446	1 252 283	15.01	2.9
1985	87 562	1 219 653	13.93	2.7
1986	102 899	1 715 391	16.39	5.2
1987	115 818	2 204 472	19.03	6.1
1988P	127 843	2 215 843	17.33	6.0

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Value is based on average reported sales.
P Preliminary.

TABLE 4. NON-SOCIALIST WORLD GOLD CONSUMPTION, 1980-87

	1980	1981	1982	1983	1984	1985	1986	1987
					(tonnes)			
Fabricated Gold Developed Countries								
Carat jewellery	315	401	456	419	474	535	553	550
Electronics	94	92	87	105	128	112	120	118
Denistry	63	64	59	50	51	52	49	45
Other uses	58	58	54	50	52	49	51	51
Medals and fake coins	18	12	6	22	16	3	4	7
Official coins	170	142	124	152	124	91	297	167
Total	718	769	786	798	845	842	1 074	938
Fabricated Gold Developing Countries								
Carat jewellery	187	373	436	392	578	592	549	589
Electronics	2	1	2	2	2	3	4	6
Denistry	2	2	2	1	1	2	2	3
Other uses	4	4	4	3	3	5	5	6
Medals and fake coins	3	15	16	9	28	11	8	8
Official coins	21	50	7	13	6	14	26	41
Total	219	445	467	420	618	627	594	653
Fabricated Gold Totals								
Carat jewellery	502	774	892	811	1 052	1 127	1 102	1 139
Electronics	96	93	89	107	130	115	124	124
Denistry	65	66	61	51	52	54	51	48
Other uses	62	62	58	53	55	54	56	57
Medals and fake coins	21	27	22	31	44	14	12	15
Official coins	191	192	131	165	130	105	323	208
Total	937	1 214	1 253	1 218	1 463	1 469	1 668	1 591

Source: "Gold 1988" - Consolidated Gold Fields PLC.

TABLE 5. GOLD MINE PRODUCTION IN THE NON-COMMUNIST WORLD

	1980	1981	1982	1983	1984	1985	1986	1987
					(tonnes)			
South Africa	675.1	657.6	664.3	679.7	683.3	671.7	640.0	607.0
Canada	50.6	52.0	64.7	73.5	83.4	87.6	102.9	114.4
United States	30.2	42.9	45.0	60.9	68.5	79.5	115.8	154.9
Other Africa								
Ghana	10.8	11.6	12.0	11.8	11.6	12.0	11.5	11.7
Zimbabwe	11.4	11.6	13.4	14.1	14.5	14.7	14.9	14.7
Zaire	3.0	3.2	4.2	6.0	10.0	8.0	8.0	12.0
Other	8.0	12.0	15.0	15.0	15.0	17.0	18.2	25.0
Total Other Africa	33.2	38.4	44.6	46.9	51.1	51.7	52.6	63.4
Latin America								
Brazil	35.0	35.0	34.8	58.7	61.5	72.3	67.4	83.8
Bolivia	2.0	2.5	2.5	3.0	4.0	6.0	6.0	6.0
Colombia	17.0	17.7	15.5	17.7	21.2	26.4	27.1	26.3
Dominican Republic	11.5	12.8	11.8	10.8	10.6	10.4	9.1	7.9
Chile	6.5	12.2	18.9	19.0	18.0	18.2	18.9	19.2
Peru	5.0	7.2	6.9	9.9	10.5	10.9	10.9	10.8
Mexico	5.9	5.0	5.2	7.4	7.5	8.0	8.3	8.3
Venezuela	1.0	1.5	2.0	6.0	9.5	12.0	15.0	16.0
Other	4.8	6.0	6.7	8.6	5.5	9.5	11.0	12.8
Total Latin America	88.7	99.9	104.3	141.1	148.3	173.7	173.7	191.1
Asia								
Philippines	22.0	24.9	31.0	33.3	34.3	36.9	38.7	39.5
Japan	6.7	5.8	5.6	5.9	7.0	9.0	14.0	13.6
India	2.6	2.6	2.2	2.2	2.0	1.7	2.1	1.6
Other	4.5	4.6	5.2	5.3	7.4	9.6	14.9	18.7
Total Asia	35.8	37.9	44.0	46.7	50.7	57.2	69.7	73.4
Europe	11.8	11.9	12.4	14.1	15.1	16.5	15.3	16.9
Oceania								
Papua New Guinea	14.3	17.2	17.8	18.4	18.7	31.3	36.1	33.9
Australia	17.0	18.4	27.0	30.6	39.1	58.5	75.1	108.0
Other	1.0	1.1	1.2	1.8	1.8	2.8	4.0	4.5
Total Oceania	32.3	36.7	46.0	50.8	59.6	92.6	115.2	146.4
Total	957.7	977.3	1 025.3	1 113.7	1 160.0	1 230.3	1 274.7	1 373.4

Source: Consolidated Gold Fields PLC, "Gold 1988," p. 20.

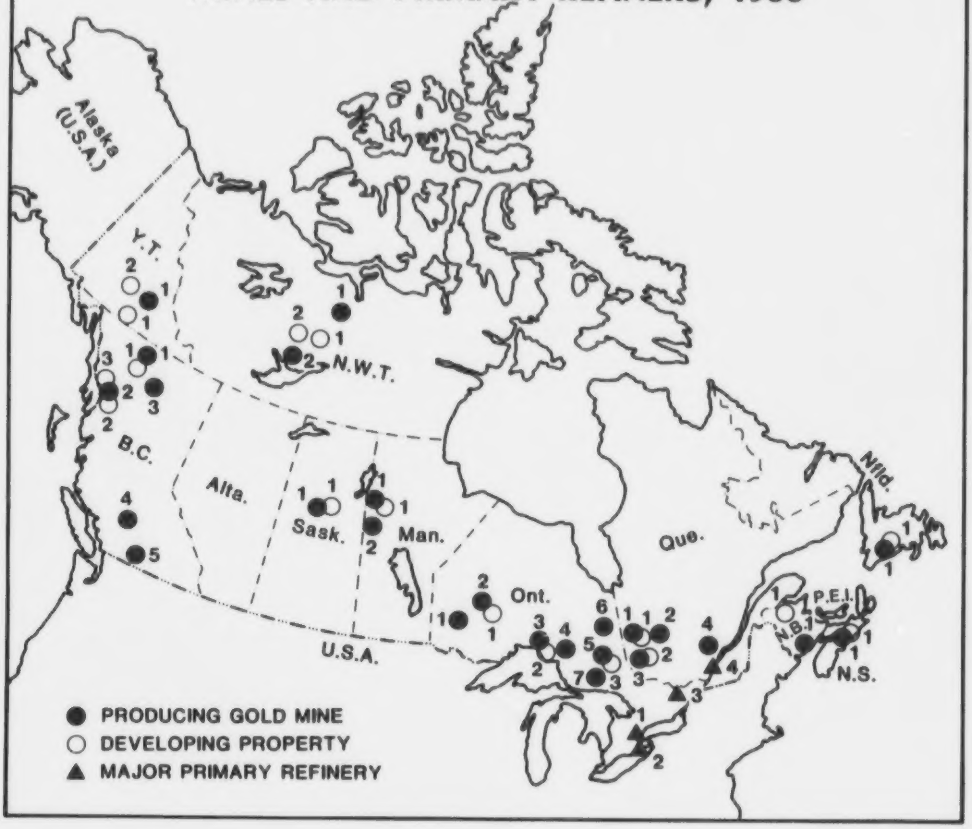
TABLE 6. AVERAGE ANNUAL GOLD PRICES 1970-88, (MONTHLY 1987 AND 1988)

Year	US$/oz.	C$/oz.	Year	US$/oz.	C$/oz.
1970	35.97	37.54	1980	614.38	719.08
1971	40.87	41.27	1981	459.22	550.57
1972	58.22	57.66	1982	375.52	463.51
1973	97.22	97.24	1983	423.52	521.82
1974	158.80	155.36	1984	360.63	466.99
1975	160.96	163.76	1985	317.35	433.21
1976	124.78	123.01	1986	367.58	510.73
1977	147.80	157.10	1987	446.66	592.18
1978	193.51	220.74	1988	436.45	554.76
1979	305.69	358.12			

Month	1987		1988	
	(US$/oz.)	(C$/oz.)	(US$/oz.)	(C$/oz.)
January	408.83	556.21	477.71	614.34
February	401.05	534.87	442.12	561.00
March	408.13	538.41	443.49	554.02
April	438.68	578.40	451.56	557.21
May	[illegible]	618.94	451.32	558.01
June	449.43	601.47	451.66	550.00
July	450.33	596.86	437.46	528.40
August	460.89	610.85	431.29	527.06
September	460.12	605.42	414.81	509.34
October	465.84	609.81	406.39	489.92
November	468.14	615.57	420.00	511.45
December	487.22	637.06	422.14	504.88

Source: London Gold Market. Compiled by Energy, Mines and Resources Canada.

PRINCIPAL CANADIAN GOLD MINES, DEVELOPING MINES AND PRIMARY REFINERS, 1988


Alaska (U.S.A.)
Y.T.
N.W.T.
B.C.
Alta.
Sask.
Man.
Ont.
Que.
Nfld.
P.E.I.
N.B.
N.S.
U.S.A.
● PRODUCING GOLD MINE
○ DEVELOPING PROPERTY
▲ MAJOR PRIMARY REFINERY

MAJOR PRIMARY GOLD REFINERIES IN CANADA, 1988

1. Johnson Matthey Limited - Brampton, Ontario
2. Degussa Canada Ltd. - Burlington, Ontario
3. Royal Canadian Mint - Ottawa, Ontario
4. Noranda Inc. - Montreal, Quebec

MAJOR PRIMARY GOLD MINES IN CANADA, 1988

Yukon Territory:

1. Belmoral Mines Ltd. - Ketza River mine

Northwest Territories:

1. Echo Bay Mines Ltd. - Lupin mine
2. Giant Yellowknife Mines Limited - Giant mine

   NERCO Minerals Company - Con mine

   Treminco Resources Ltd. - Ptarmingan and Tom mines

British Columbia:

1. TOTAL Energold Corporation - Erickson mine
2. Skyline Explorations Ltd. - Johnny Mountain mine
3. Cheni Gold Mines Inc. - Lawyers mine
4. Blackdome Mining Corporation - Blackdome mine
5. Corona Corporation - Nickel Plate mine

Saskatchewan:

1. Cameco - A Canadian Mining & Energy Corporation - Star Lake mine

   International Mahogany Corp. - Jolu mine

Manitoba:

1. LynnGold Resources Inc. - MacLellan and Nisku mines
2. Granges Exploration Ltd. - Tartan Lake mine

   Pioneer Metals Corporation - Puffy Lake mine

Ontario:

1. Red Lake Area
   - Placer Dome Inc. - Campbell mine
   - Dickenson Mines Limited - Arthur W. White mine
2. Pickle Lake Area
   - Bond Gold Canada Inc. - Golden Patricia mine
3. Hemlo Area
   - Lac Minerals Ltd. - Page-Williams mine
   - Hemlo Gold Mines Inc. - Golden Giant mine
   - Teck-Corona Operating Corporation - David Bell mine
4. Wawa Area
   - Renabie Gold Mines Limited - Renabie mine
   - Canamax Resources Inc. - Kremzar mine
   - Muscocho Explorations Ltd. - Magino mine
5. Timmins - Kirkland Lake Area
   - Placer Dome Inc. - Dome Mine
   - Giant Yellowknife Mines Limited - Pamour #1, Timmins, Ross and Schumacher mines
   - Falconbridge Gold Corporation - Owl Creek and Hoyle Pond mines
   - Lac Minerals Ltd. - Macassa and Lake Shore mines
   - American Barrick Resources Corporation - Holt-McDermott mine
   - Canamax Resources Inc. - Bell Creek mine
   - ERG Resources Inc. - Timmins Tailings Project
   - Eastmaque Gold Mines Ltd. - Kirkland Lake Tailings Project
   - Golden Shield Resources Ltd. - Kerr mine
6. Placer Dome Inc. - Detour Lake mine
7. Noramco Mining Corporation - Golden Rose mine

Quebec:

1. Northwestern Area
    - Agnico-Eagle Mines Limited - Telbel mine
    - INCO Limited, Golden Knight Resources Inc. - Golden Pond East mine
2. Desmaraisville - Chibougamau Area
    - Minnova Inc. - Lac Shortt mine
    - Quebec Sturgeon River Mines Limited - Bachelor Lake mine
    - Campbell Resources Inc. - Joe Mann mine
3. Noranda/Rouyn - Val d'Or Area
    - Rouyn Mining Resources Inc. - Francoeur mine
    - Lac Minerals Ltd. - Doyon and Bousquet mines
    - Dumagami Mines Limited - Donald LaRonde mine
    - American Barrick Resources Corporation - Camflo/Malartic Hygrade mine
    - Malartic Hygrade Gold Mines (Canada) Ltd. - Orion mine
    - Kiena Gold Mines Limited - Kiena mine
    - Placer Dome Inc. - Sigma mine
    - Belmoral Mines Ltd. - Ferderber and Dumont mines
    - Amalgamated d'Or Val Perron Mines Ltd. - Beacon mine
    - Audrey Resources Inc. - Morbrun mine
    - Aur Resources Inc. - First Canadian mine
    - Cambior inc. - Pierre Beauchemin mine
4. Muscocho Explorations Ltd. - Montauban mine

New Brunswick:

1. Gordex Minerals Limited - Cape Spencer mine

Nova Scotia:

1. Westminer Canada Limited - Beaver Dam and Forest Hill mines
   Coxheath Gold Holdings Limited - Tangiers mine

Newfoundland:

1. Hope Brook Gold Inc. - Hope Brook mine

DEVELOPING GOLD MINES IN CANADA, 1988

Yukon Territory:

1. TOTAL Energold Corporation - Mt. Skukum
   Omni Resources Inc. - Skukum Creek
2. B.Y.G. Natural Resources Inc. - Brown McDade property

Northwest Territories:

1. Noranda Inc. - Tundra
2. Neptune Resources Corp. - Colomac

British Columbia:

1. Chevron Canada Limited/Homestake Mining Company - Golden Bear property
2. Westmin Resources Limited/Pioneer Metals Corporation - Premier property
3. Cominco Ltd./Delaware Resources Corp. - SNIP property
   Skyline Explorations Ltd. - Reg property

Saskatchewan:

1. Claude Resources Inc. - Seabee property
2. Cameco/Golden Rule Resources Ltd. - Fork Lakes property

Manitoba:

1. LynnGold Resources Inc. - Rainbow property

Ontario:

1. Placer Dome Inc. - Dona Lake
2. Flanagan McAdam Resources Inc. - Magnacon property
3. St. Andrew Goldfields Ltd. - Stock Twp. property

Quebec:

1. INCO Gold Company/Golden Knight Resources Inc. - Golden Pond West
   Teck Corporation/Golden Hope Resources Inc. - Estrades property
2. Lac Minerals Ltd. - Bousquet #2
   Yorbeau Resources Inc. - Astoria property
   Noranda Inc. - Silidor property

New Brunswick:

1. NovaGold Resources Incorporated - Murray Brook property

Nova Scotia:

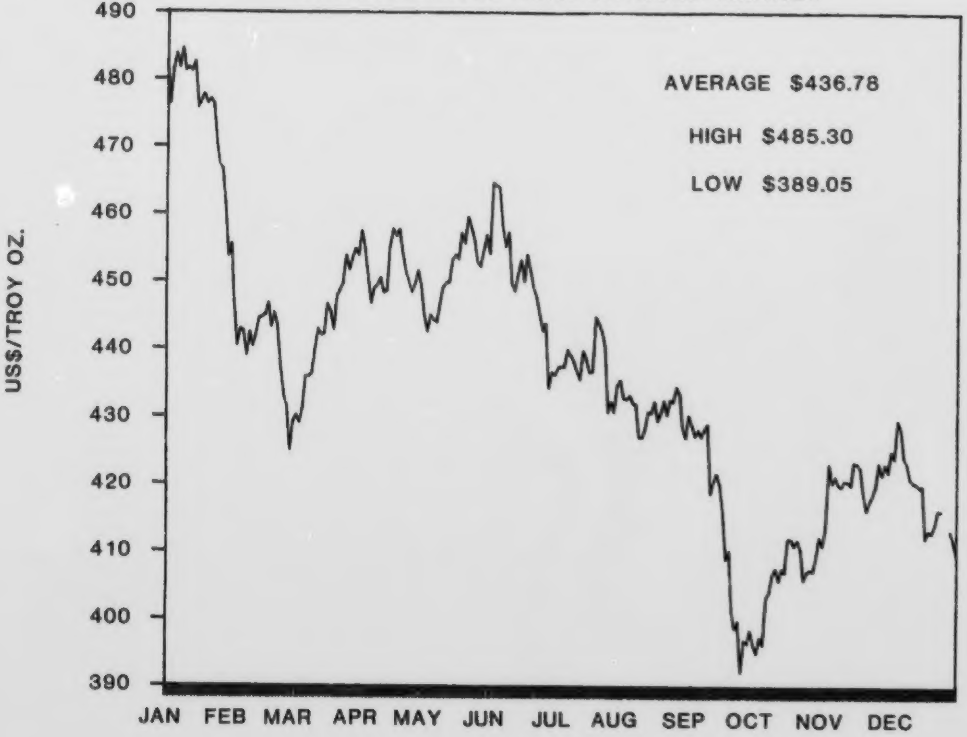
1. NovaGold Resources Incorporated - Cochrane Hill property
   NovaGold Resources Incorporated - Fifteen Mile Stream property

Newfoundland:

1. Dolphin Explorations Ltd. - Cape Ray property

DAILY GOLD PRICES 1988

AVERAGE FIXES LONDON GOLD MARKET



Graphite

M.A. BOUCHER

SUMMARY

Asbury Graphite Quebec Inc. remained Canada's only producer of natural graphite in 1988. The company had undertaken a modernization program in 1986 and shipments had almost completely been discontinued that year. Production and shipments resumed in 1987 and were increased in 1988.

Consumption of graphite in Canada in 1987, the latest year for which statistics are available was 14 217 t, compared with 13 757 t in 1986. About 35% of graphite consumption is natural graphite, of which 90% is flake. Most graphite is used as foundry facing, in metallurgy and refractory industries.

Imports of crude graphite for the first nine months of 1988 were valued at $2.30 million. Imports for twelve months in 1987 were $3.61 million. Nearly all graphite produced in Canada is exported to the parent company in the United States.

During 1988, most exploration and development work was carried out in Ontario and Quebec.

World demand for natural graphite continued strong in 1988. At year-end published prices which had been stable for the past four years were increased considerably on all products.

NATURAL GRAPHITE

Graphite is a natural form of carbon. Natural graphite is a lustrous, black carbon mineral, crystallized in the hexagonal system with rhombohedral symmetry. Flake graphite is opaque, flexible and sectile, and exhibits perfect basal cleavage. Natural graphite is unctuous and is relatively soft with a hardness of 1 to 2 on Mohs' scale. It has a black colour and a black streak on glazed porcelain. Its specific gravity is 2.266 g/cm^3. Graphite is an excellent conductor of heat and electricity, and it has a high melting temperature of 3000°C. It is extremely resistant to acid, chemically inert and highly refractory.

Natural graphite is widely distributed throughout the world and is of common occurrence in metamorphic rocks produced by regional or contact metamorphism. Commercially, natural graphite is classified as amorphous, crystalline lump (or vein) and flake. Amorphous graphite is a microcrystalline graphite formed by crystallization of the carbon from organic sediments such as coal. The graphite occurs as distorted seams of minute microcrystalline particles intermixed with ungraphitized materials. The graphite content may vary from 15% to 98%, depending on the degree of metamorphism and the original carbon content in the sediments. Crystalline lump occurs in the form of massive vein or circular accumulation formed probably from hydrothermal origin. Deposits are found in fissures, or other cavities in igneous or metamorphic rocks. The size of the particles varies from fine grains to large lumps. The vein deposits vary widely in width from 2 mm to more than 2 m. Flake graphite is found disseminated in metamorphosed siliceous or calcareous sediments such as marble, gneiss and schist.

Flake is defined as thin flakes which could be classified from coarse to fine and which are graded according to their graphitic carbon content.

Occurrences

Graphite deposits in Canada occur principally in rocks of the Grenville series of eastern Canada. The mineral is found in disseminated crystalline flake and vein forms. Most Canadian graphite deposits are associated with graphite gneiss and crystalline limestones which have been subjected to contact metamorphism associated with tectonic features such as folding, compression and fracturing, and with pegmatitic intrusions. The richest ore zones occur as a succession

---

M.A. Boucher is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 992-3074.

of veins or lenticular bodies that gradually merge into the adjacent non-graphititic host rock and that are bordered by lenses of lower-grade ore.

Flake graphite deposits have been reported mainly in Quebec and Ontario, but also in New Brunswick, Nova Scotia, and Saskatchewan.

In Quebec, graphite deposits are located mainly along the Grenville series in several townships of western Quebec: Buckingham, Argenteuil and Pontiac. The disseminated flake graphite variety is dominant, in biotite gneiss and crystalline limestone associated with biotite quartzite, but the vein variety is also reported along the contact of intrusive rocks and crystalline limestone. Occurrences of graphite are associated with metasedimentary rocks which have been subjected to several deformation phases and where metamorphism has reached amphibolitic or granulitic phases.

Graphite also occurs in Esmanville township, south of Fermont. Several graphite-rich schist zones measuring 1 to 25 m in thickness are found interlayered with quartz-feldspar gneiss. Some graphite zones contain locally more than 15% graphite in the form of fine and well crystallized flakes.

In Ontario, graphite deposits are found in several townships of eastern Ontario in rocks of the Grenville Geological Province. Flake graphite occurs disseminated in marbles and gneiss. The occurrences of major interests are in semipelitic and pelitic gneiss units within paragneiss sequences. Graphite is present in amounts up to 10%. Accessory minerals consist of biotite, garnet and pyrite; trace elements in these graphitic rocks are nickel, cobalt, boron and vanadium.

CANADIAN PRODUCTION, EXPLORATION AND DEVELOPMENT

In 1988, Canada's production of graphite came from Asbury Graphite Quebec Inc. of Notre-Dame-du-Laus, Quebec. Asbury Graphite is a subsidiary of Asbury Carbons Inc. of the United States, a holding company with mining operations in Canada and Mexico, and custom processing plants in the United States for grinding, screening, and blending graphite ores and petroleum cokes, along with other specialty carbon types.

At Notre-Dame-du-Laus, Asbury Graphite operates a small open-pit mine on an intermittent basis. The ore is a disseminated flake graphite in crystalline limestone associated with biotite quartzite. Graphite ore grades between 7 to 10% carbon content, averaging 8% carbon. Open-pit reserves are estimated at 300 000 t. Asbury Graphite produces flaky graphite in three sizes -400 um, 150-400 um and -150 um with carbon content of 85 to +90%. Approximately 70% is flakes and 30% powder. Employment is 30-32.

The year 1988 was marked by active exploration and development work in both Ontario and Quebec. The major companies involved were primarily Cal Graphite Corporation and Stewart Lake Resources Inc. of Ontario, and Stratmin Inc. of Quebec.

Other companies involved in graphite exploration were Victoria Graphite Inc. in Ontario and Mazarin Mining Exploration Inc. in Quebec.

Cal Graphite Corporation of Lively, Ontario, holds a 100% interest in mining claims in the Township of Butt near Huntsville where crystalline flake graphite occurs in mafic gneiss and paragneiss. Since 1985, Cal Graphite Corporation has undertaken exploration work and in a 1986 study, the company reported it had outlined some 30 Mt of proven and probable reserves grading 2.5 to 3.5% graphitic carbon measured by double ignition loss. More exploration was carried out in 1987 and 1988 and at year-end 1988 the company reported that reserves had virtually been doubled. An open-pit mine and a processing plant with an eventual production capacity of 5 000 t/d ore is under construction. Production is expected to start in 1989 at an initial rate of 1 000 t/d, and will eventually be increased to full capacity of 5 000 t. Although the grade of the ore is relatively low, the company reports that only light crushing will be necessary to free the crystalline flakes, and a simple upgrading process including autogenous rotary crushing and vertical column flotation will be used. Flake graphite concentrates grading 90 to 94% carbon will be sold to crucible, lubricant and refractory companies, mainly in the United States and Europe. A refinery to produce higher grade concentrates at Sudbury is planned by the company.

Stewart Lake Resources Inc. continued drilling at its Kirkham Lake property near Godfrey, Ontario. So far, the company has reported proven reserves of 1.5 Mt of high grade (undefined by the company) flake ore and indicated reserves of 5.0 Mt ore averaging 7.6% carbon.

A prefeasibility study prepared in 1988 recommended the underground mining of 300-350 t/d of high grade ore for an annual production of 14 000 t/y of concentrates. The final feasibility study should be completed in early 1989.

Victoria Graphite Inc. continued drilling its graphite deposits near Portland, Ontario where graphite occurs near the surface in silicated marble in three steeply dipping zones.

Princeton Resources Corporation had its name changed during the year to Canadian Graphite Ltd. The company did not report any new activity in 1988, but since 1984 it has been working on the development of a flake graphite deposit near Bissett Creek, Ontario. Reserves in excess of 16 Mt of ore averaging 3.2% carbon have been delineated. A feasibility study has also been prepared by KHD Canada Inc. on an open cast mining and processing operation capable of producing some 17 000 t/y of marketable flake graphite grading 90-92% carbon.

Stratmin Inc. of Montreal, Quebec and Asbury Graphite Mills Inc. of Asbury, New Jersey have reached a fifteen year agreement with options for subsequent five year renewals. The agreement calls among others for Stratmin to lease and operate Asbury's milling facilities in Notre-Dame-du-Laus, Quebec. The mill will be modified and winterized and production at an annual rate of 9 000 t/y concentrate, with full year-round production start up scheduled for February 1989. Asbury is committed to purchase the total production of the first year and a minimum of 5 000 t/y concentrate for a minimum of 5 years with subsequent 5 year renewals.

Stratmin will build a 500 t/d mill to produce 10 000 t/y of graphite concentrates at its Lac-des-Îles graphite property near Mont-Laurier, Quebec and construction should be completed during 1989.

From Stratmin's new milling facilities, Asbury is committed to purchase 5 000 t of concentrates of Stratmin's initial first year production.

Asbury's total commitment for the first year is for 14 000 t of concentrates produced by Stratmin.

An agreement in principle has also been reached with C. ITOH Ceramics Corp. of Japan whereby the latter will buy 5 000 t of concentrate annually over a 5-year period, with 5-year renewals possible. Prices will be negotiated annually.

Total reserves (proven, probable, possible) of Stratmin's Lac-des-Îles properties are 23.7 Mt averaging 7.5% carbon. Mining will be by open cast method from four pits. Concentrates of 92 to 98% carbon will be produced.

Mazarin Mining Exploration Inc. of Quebec continued exploration on its Lac Knife and Lac Carheill properties, south of Fermont in northern Quebec. Channel samples at Lac Knife have indicated an average grade of 15.7% carbon. The company plans 3 000 m of drilling on its graphite properties in 1989.

CANADA, CONSUMPTION AND TRADE

Reported consumption of graphite in 1987 amounted to 14 217 t. Graphite was mainly used in foundries, metallurgy and refractories. Nearly all production of graphite produced by Asbury Graphite is exported to its parent company in the United States.

In 1988, imports of crude graphite for the first nine months were valued at $2.30 million. Some 90% of Canada's imports originate from the United States. Crude graphite is used mainly in Ontario (70%) and Quebec (15%).

USES AND SPECIFICATIONS

The uses of natural graphite depend on its physical and chemical properties. The strength of graphite increases as its temperature rises. It has a high thermal conductivity and a low absorption coefficient for X-rays and electrons.

Flake graphite is used in the manufacture of crucible for the steel, nonferrous and precious metals industries. It is preferred to microcrystalline graphite because it burns more slowly, has a high attrition resistance and imparts structural strength through the orientation of the flakes.

Carbon refractories are classified as including more than 7% carbon in a blend with either microcrystalline or flake graphite, and are known as magnesia carbon brick. Mag-Carbon brick is used in high temperature and corrosion prone applications such as in steel furnace lining, ladles, slag-lines, hotpots, nozzles and blast furnaces. Graphite is used because of its thermal conductivity, and thermal and chemical resistances. Flake graphite must have a carbon content between 90 and 97% and sizes ranging from 75 to 180 microns.

The use of graphite in brake linings reduces the wear rate. High carbon fine crystalline graphite, below 75 microns, is used with a minimum carbon content of 98%, although a concentrate of 90% can be used if abrasive impurities such as silica are at a low level.

Traditionally, graphite has been used in dry cell zinc-carbon batteries due to its electrical conductivity. Fine grain carbon, below 75 microns, or microcrystalline graphite with a minimum carbon content between 85 to 90% is required. Alkaline batteries require a purer natural graphite with a carbon content of at least 98% or a synthetic grade. Carbon material should be free of metallic impurities such as copper, cobalt or antimony.

Electric motor components use a wide variety of graphite, natural or synthetic. Powdered graphite, 150 microns, with a minimum carbon content of 95 to 99% is used. Lump graphite, low-silica microcrystalline graphite and synthetic graphite are usually utilized.

In powder metallurgy where steel is reinforced by the absorption of carbon, high purity graphite is required for the sintering. It also acts as a lubricant and as a source of carbon. Dry powder graphite should be of an average particle size of 5 microns and must have a carbon content between 96 to 99%.

Lubricants for industrial usage are also made from graphite because of its softness, low friction, inertness and heat resistance. High carbon fine crystalline graphite, below one micron, is specified with a carbon content of 96 to 99%.

In paint manufacture, graphite is used to protect metal surfaces exposed to corrosive environment, and to eliminate the accumulation of static electricity in floor coating. Microcrystalline graphite of low carbon content, 50 to 55%, is usually required.

In the manufacture of lead pencil, natural graphite is used because of its marking properties. The degree of hardness of a pencil is determined by the clay to graphite ratio of its lead. Microcrystalline graphite, 80 to 82%, is used in the cheaper grades of leads. However, a finely ground graphite with a higher carbon content, over 90%, is usually required.

For foundry application such as mould coating, graphite prevents the adhesion of metals. Foundry facings are usually made of lump graphite or microcrystalline graphite, between 53 to 75 microns, with a low carbon content, 40 to 70%.

Iron foundries use microcrystalline graphite as a recarburizer for raising the carbon content of iron melted in electrical furnace from charges containing large proportions of scrap. A wide variety of material may serve as a substitute: synthetic graphite and coke.

Other uses for natural graphite include engineering components, polishes, rubber products and explosives.

Expected growth areas are in the use of exfoliated flake graphite rolled into sheet for the manufacture of gaskets and seals used in the automotive industry, and in the form of expanded graphite for use as fire-retardant in foam filled furniture.

WORLD PRODUCTION, TRADE AND CONSUMPTION

Preliminary figures indicate that world production of natural graphite was 668 300 t in 1986. About 40% was flake graphite. China is reported to be the largest producer with 185 000 t, followed by South Korea 97 000 t, the U.S.S.R. 83 000 t, Czechoslovakia 59 000 t, India 38 000 t, Brazil 37 000 t, and Mexico 36 000 t. As indicated in Table 2 world production has increased 213 000 t/y from 1976 to 1986; this represents about 21 000 t/y, or the size of a large graphite mining operation.

The major world producers by type of graphite and by decreasing order of importance are as follows:

Flakes:
China, Brazil, India, U.S.S.R., Madagascar, West Germany, Norway.

Microcrystalline:
China, South Korea, Mexico, Czechoslovakia, Austria, U.S.S.R., North Korea, Zimbabwe.
Lump:
Sri Lanka.

A resume of the largest exporters and importers of graphite in recent years are as follows:

MAJOR EXPORTERS AND IMPORTERS OF GRAPHITE IN RECENT YEARS

	Exports (000 t/y)		Imports (000 t/y)
China	70-80	Japan	70-90
South Korea	35-45	United States	40-47
Mexico	20	West Germany	30-35
Madagascar	15	United Kingdom	20-22
Zimbabwe	13	Taiwan	8
Austria	10	Italy	6
West Germany	10	France	5
Brazil	9	Austria	4
Norway (when exports resume)	5-7		

The largest consumers of graphite are the large producers of iron and steel, base metals and precious metals. Together they consume about 50% of all graphite and they are the largest users of flake graphite. The largest consumers are: U.S.S.R., Japan, United States, China, West Germany, United Kingdom, Italy, France and Brazil.

PRICE

Published prices for natural graphite provide only a range of prices and are not representative of market prices which are contracted prices negotiated between suppliers or distributors and consumers. The prices of flake graphite and lump graphite are higher than those for microcrystalline (amorphous)graphite because of the nature of mining and processing operations. Prices for flake graphite concentrate vary depending on the carbon content, the size of the flakes and their distribution, and the ash content.

Published prices c.i.f. United Kingdom ports were increased considerably at year end from 30 to 60 percent for some products.

OUTLOOK

Graphite has excellent physical and chemical properties; its resource base is large and it is readily available from several countries. For these reasons, growth should continue.

The grade of Canadian deposits is generally lower than that of most producers in the world. Also, labour costs in Canada are relatively high compared to those in many producing countries. However, Canadian deposits are of the flake type and many contain graphite that is expandable; these products command high prices and the outlook for growth is good. Countries that rely mainly on China for their supplies of flake graphite may wish to diversify their sources.

PRICES

"Industrial Minerals"[1] pricing quotation, c.i.f., United Kingdom port, US$ per tonne

	Dec. 1984	1988	
		Nov.	Dec.
Crystalline lump, 92-99% C	550 - 1 100	550 - 1 100	750 - 1 500
Crystalline large flake, 85-90% C	630 - 1 000	630 - 1 000	820 - 1 300
Crystalline medium flake, 85-90% C	490 - 860	490 - 860	770 - 1 120
Crystalline small flake, 80-95% C	300 - 800	300 - 800	540 - 900
Powder (200 mesh), 80-85% C	250 - 275	250 - 275	325 - 360
90-92% C	410 - 460	410 - 460	520 - 600
95-97% C	550 - 750	550 - 750	770 - 1 000
97-99% C	750 - 1 000	750 - 1 000	1 000 - 1 300
Amorphous powder, 80-85% C	175 - 350	175 - 350	220 - 440

"Chemical Marketing Reporter"[2], pricing quotation, New York, U.S. basis, bags, drums, US$ per pound

	1987	1988
Crystalline, powder, 88-90%	.30 - .60	.30 - .60
90-92%	.40 - .70	.40 - .75
95-96%	.60 - .90	.60 - .90
97% and up	.80 - 1.20	.80 - 1.20
Flake, No. 1 (large), 90-95%	.65 - .75	.65 - .75
No. 2 (medium), 90-95%	.65 - .75	.65 - .75
No. 3 (small), 90-95%	.65 - .75	.65 - .75
Amorphous, powder	.16 - .40	.16 - .40
powder, 97% and up	.80 - 1.20	.80 - 1.20

---

[1] "Industrial Minerals", December 1984, November and December 1988. [2] "Chemical Marketing Reporter", December 1987 and December 1988.
c.i.f. Cost, insurance and freight.

TARIFFS

Item No.	Description	Canada MFN	Canada GPT	Canada USA	United States Canada
25.04	Natural graphite				
2504.10.10	--- in powder	9.2%	6%	Free	Free
2504.10.20	--- in flakes	4%	2.5%	Free	Free
69.02	Refractory bricks, blocks, tiles and other ceramic goods of siliceous fossil meals, or of similar siliceous earths				
6902.90.10	--- containing by weight 85% or more of carbon or graphite	6.8%	4.5%	6.1%	Free
6902.90.90	--- Other, containing by weight more than 50% but less than 85% of carbon or graphite	Free	Free	Free	4.4%
69.03	Other refractory ceramic goods, other than those of siliceous fossil meals or of other similar siliceous earths				
6903.10	- containing by weight more than 50% of graphite or other forms of carbon or of a mixture of these products				
6903.10.10	- crucibles and covers therefor	6.8%	Free	6.1%	4.4%
8545.20	Carbon or graphite brushes	10.2%	6.5%	9.1%	3.3%

Sources: Customs Tariffs, effective January 1989, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States (First Edition Supplement 2) effective January 1, 1989.

TABLE 1A. IMPORTS OF CRUDE GRAPHITE AND GRAPHITE RELATED PRODUCTS INTO CANADA, 1986 AND 1987

	1986		1987	
	(tonnes)	($000)	(tonnes)	($000)
Graphite, crude				
United States	..	2 681	..	3 021
West Germany	..	131	..	194
Switzerland	..	46	..	263
Other countries	..	119	..	136
Total	..	2 977	..	3 614
Graphite and carbon brush stock				
United States	110	1 924	237	1 960
West Germany	3	42	...	5
Other countries	1	28	...	8
Total	114	1 994	237	1 973
Graphite and carbon crucibles				
United States	..	687	..	692
United Kingdom	..	112	..	51
France	..	4	..	11
Other countries	..	48	..	2
Total	..	851	..	756
Graphite and carbon refractories, n.e.s.				
United States	..	1 565	..	1 582
West Germany	..	1 292	..	1
United Kingdom	..	117	..	138
Japan	..	-	..	1 179
Other countries	..	83	..	2
Total	..	3 057	..	2 902

Source: Statistics Canada.
- Nil; .. Not available; n.e.s. Not elsewhere specified; ... Amount too small to be expressed.
Totals may not add due to rounding.

TABLE 1B. IMPORTS OF CRUDE GRAPHITE AND GRAPHITE RELATED PRODUCTS, 1988P

Item No.		1988P Jan.-Sept.	
		(tonnes)	($000)
2504.10	Natural graphite in powder or flake		
	United States	2 748	1 861
	Switzerland	67	337
	West Germany	48	35
	Other countries	49	72
	Total	2 912	2 305
6902.90	Refractory bricks, etc. n.e.s., (containing by weight more than 50% carbon or graphite)		
	United States	179 479	30 726
	West Germany	2 958	3 151
	Japan	2 219	4 328
	United Kingdom	824	1 065
	Other countries	4 347	350
	Total	189 827	39 620
6903.10	Refractory ceramic goods, n.e.s., more than 50% of graphite or other forms of carbon, etc. (including crucibles)		
	United States	..	1 259
	United Kingdom	..	217
	France	..	163
	Other countries	..	280
	Total	..	1 919
8545.20	Carbon or graphite brushes		
	United States	365	2 115
	West Germany	11	104
	Japan	10	54
	Other countries	3	22
	Total	389	2 295

Source: Statistics Canada.
P Preliminary; .. Not available; n.e.s. Not elsewhere specified.

TABLE 2. GRAPHITE, WORLD PRODUCTION, ALL TYPES, 1976 AND 1984-86

Country	1976	1984	1985	1986^{P}	Type of Graphite
		(tonnes)			
China^{e}	50 000	184 000	185 000	185 000	flakes, microcrystalline
U.S.S.R.^{e}	95 000	80 000	82 000	82 600	flakes, microcrystalline
Czechoslovakia^{e}	45 000	50 000	59 000	59 000	microcrystalline
South Korea	42 330	56 250	69 900	96 600	microcrystalline
(South Korea)	-	2 300	1 600	640	flakes
Mexico	60 000	40 000	33 500	35 950	microcrystalline
(Mexico)	-	1 500	1 900	1 840	flakes
Austria	33 000	43 790	30 770	36 200	microcrystalline
India	38 300	36 000	27 340	38 400	flakes, run of mill
Brazil	6 000	32 600	43 670	37 000^{e}	flakes
North Korea^{e}	20 000	25 400	25 400	25 400	microcrystalline
Madagascar	17 000	13 550	14 000	16 200	flakes
Zimbabwe	8 100	12 300	10 450	15 000	microcrystalline
West Germany	14 000	12 400	12 800	13 200	flakes
Sri Lanka	8 200	5 600	7 400	7 450	crystalline vein
Norway	9 000	9 500	2 300^{e}	-	flakes
Others	9 800	19 910	16 930	17 820	all types
Total	455 400	625 100	623 960	668 300	

Source: U.S. Bureau of Mines, Graphite by Harold Taylor, 1987.
^{P} Preliminary; ^{e} Estimated; - Nil.

TABLE 3. REPORTED CONSUMPTION OF GRAPHITE IN CANADA, 1975, 1980, 1983-87

	1975	1980	1983	1984	1985	1986	1987^{P}
				(tonnes)			
Reported consumption[1] of graphite							
Foundry facing	3 822	3 078	4 309	5 297	6 132	10 294	10 003
Ferroalloys and primary steel	568	468	356	475	398	795	950
Refractories	523	583	515	761	472	757	740
Other[2]	429	1 788	1 189	1 887	1 335	1 911	2 524
Total	5 342	5 917	6 369^{r}	8 420^{r}	8 337^{r}	13 757	14 217

[1] Reported from EMR survey on the consumption of nonmetallic minerals by Canadian manufacturing plants. [2] Includes brake linings, chemicals, abrasives, batteries and other end-uses.
^{P} Preliminary; ^{r} Revised.

TABLE 4. UNITED STATES IMPORTS FOR CONSUMPTION OF GRAPHITE, BY COUNTRY

Year and Country	Crystalline Flake		Other Natural Crude and Refined[1]	
	Quantity (short tons)	Value ($000)	Quantity (short tons)	Value ($000)
1986	4 821	3 122	37 969	12 636
1987				
Brazil	1 019	622	4 763	2 754
Canada	977	554	1 152	548
China	1 827	963	9 837[2]	3 302[2]
West Germany	22	99	269	761
Italy	-	-	-	-
Japan	83	295	403	780
Madagascar	2 519	2 086	1 325	975
Mexico	-	-	20 713[3]	1 682[3]
Sri Lanka	-	-	1 402	1 137
Other	127	64	1 330[4]	1 032[4]
Total	6 574	4 683	41 194	12 971

Source: U.S. Bureau of Mines, Graphite in 1987 by Harold A. Taylor, Jr.

[1] Includes lump graphite, amorphous graphite, and fine crystalline flake. [2] Includes 741 tons of amorphous graphite worth $80 000. [3] Includes 19 321 tons of amorphous graphite worth $1.00 million. [4] Includes 141 tons of amorphous graphite worth $45 000.

- Nil.

TABLE 5. UNITED STATES CONSUMPTION OF NATURAL GRAPHITE, BY USE

Use	Crystalline		Amorphous[1]		Total[2]	
	Quantity (short tons)	Value ($000)	Quantity (short tons)	Value ($000)	Quantity (short tons)	Value ($000)
1986						
Batteries	W	W	W	W	1 302[r]	1 824[r]
Brake linings	1 453	1 294	2 632	2 112	4 085	3 406
Carbon products[3]	406	1 025	211	249	617	1 274
Crucibles, retorts, stoppers, sleeves, nozzles	1 516	1 333	14	15	1 530	1 348
Foundries[4]	553	356	3 916	1 279	4 469	1 635
Lubricants[5]	832	970	3 824	3 177	4 656	4 147
Pencils	1 740	2 334	286	213	2 026	2 547
Powdered metals	459	802	111	165	570	967
Refractories	W	W	W	W	8 020	3 790
Rubber	221	258	155	86	376	344
Steelmaking	131	70	1 546	607	1 677	677
Other[6]	94	212	2 049	2 298	2 143	2 510
Withheld uses	6 499[r]	4 962[r]	2 823	652	..	..
Total[2]	13 904[r]	13 616[r]	17 568	10 853	31 472[r]	24 469[r]
1987						
Batteries	W	W	W	W	1 102	1 702
Brake linings	1 627	1 408	2 643	2 745	4 270	4 153
Carbon products[3]	361	868	219	270	580	1 138
Crucibles, retorts, stoppers, sleeves, nozzles	W	W	W	W	1 506	1 411
Foundries[4]	436	281	4 345	1 321	4 781	1 602
Lubricants[5]	805	789	3 606	2 296	4 411	3 085
Pencils	1 857	2 047	271	164	2 129	2 211
Powdered metals	461	848	121	190	582	1 038
Refractories	W	W	W	W	8 300	3 682
Rubber	130	152	279	141	409	293
Steelmaking	167	111	1 369	538	1 536	649
Other[6]	73	163	2 487	2 750	2 560	2 913
Withheld uses	6 559	5 828	4 348	967	..	..
Total[2]	12 475	12 494	19 690	11 383	32 165	23 876

Source: U.S. Bureau of Mines, Graphite in 1987 by Harold A. Taylor, Jr.

[1] Includes mixtures of natural and manufactured graphite. [2] Data may not add to totals shown because of independent rounding. [3] Includes bearings and carbon brushes. [4] Includes foundry facings. [5] Includes ammunition, packings, and seed coating. [6] Includes paints and polishes, anti-knock and other compounds, soldering and/or weld, electrical and electronic products, mechanical products, magnetic tape, small packages, industrial diamonds and drilling mud.

[r] Revised; .. Not available; W Withheld to avoid disclosing company proprietary data, included with "Withheld uses."

TABLE 6. SELECTED IMPORTS OF GRAPHITE

Country	1984	1985	1986	1987
		(tonnes)		
United Kingdom	19 540	23 460	23 101	19 729
France	4 578	5 277	5 572	5 864
West Germany	31 983	33 998	37 793	30 504
Italy	6 280	5 955	6 867	..
Netherlands	954	636	1 204	1 726
Spain	2 004	2 519	3 993	..
Austria	7 134	3 280	4 966	2 083
East Germany	5 712	6 634	5 289	..
Poland	7 445	6 082	3 929	..
Yugoslavia	2 220	2 267	2 234	2 415
South Africa	4 122	3 834	2 751	..
Mexico	14	46	-	..
United States	52 840	47 842	38 817	43 335
Venezuela	701	927	681	..
Hong Kong	1 545	1 499	3 685	4 104
India[1]	-	-	-	-
Indonesia	98	150	968	..
Japan	85 009	78 857	58 645	94 268
Korea, Republic of	1 260	1 084	3 180	..
Malaysia	1 183	908	510	..
Pakistan[2]	1 777	1 566	845	2 630
Taiwan	6 574	8 428	8 513	8 390
Australia	979	1 199	1 460	..

Source: British Geological Survey, World Mineral Statistics.
[1] Years ended March 31. [2] Years ended June 30.
- Nil; .. Not available.

TABLE 7. SELECTED EXPORTS OF GRAPHITE

Country	1984	1985	1986	1987
		(tonnes)		
United Kingdom	3 862	2 563	3 739	3 184
West Germany	12 210	11 522	9 844	10 287
Austria	11 552	11 826	10 284	8 330
Czechoslovakia[1]	2 800	3 100	2 800	..
Norway	8 888	6 161	954	56
U.S.S.R.[1]	-	-	-	..
Madagascar	14 527	16 125	13 595	..
Zimbabwe	11 989	15 440	14 700	12 503
Mexico	21 323	19 298	-	..
United States	6 667	9 240	13 089	15 000
Brazil	5 082	8 725	9 890	..
China[1]	78 800	71 800	80 100	..
Hong Kong (re-exports)	856	508	3 036	3 781
India[2]	1 871	1 043	-	..
Japan	2 927	2 553	2 666	2 019
North Korea[1]	11 000	5 800	4 600	..
South Korea	39 864	48 353	30 969	..
Sri Lanka	7 215	9 170	9 824	10 388
Taiwan	237	188	204	178

Source: British Geological Survey, World Mineral Statistics.

[1] British Geological Survey estimates, based on known imports into certain countries.

[2] Years ended March 31.

- Nil; .. Not available.

Note: This table excludes synthetic graphite.

Gypsum and Anhydrite

O. VAGT

SUMMARY

In response to slightly weaker demand for gypsum wallboard by the building construction industry in the United States, exports of crude gypsum particularly from Atlantic Canada, along with production (shipments), were about 6% lower than 1986-87 levels. Total Canadian shipments were 8.5 Mt in 1988, according to preliminary figures. Exports of gypsum wallboard to the United States declined an estimated 10% in 1988 from 72.6 million m^2 in 1987 (12 months), based on available preliminary data. U.S. housing starts in 1988 were running about 10% behind 1987, based on 10-month data. Canadian demand for wallboard dropped mainly as a result of weaker residential construction in Ontario and Quebec. Housing starts in 1988 were about 220 000 down from 246 000 in 1987, according to preliminary figures.

Canadian operations are largely subsidiaries of United States gypsum products producers. Production of crude gypsum is mainly from Atlantic Canada which accounts for over 75% of production and most exports. Ontario production is used on-site except in the case of Westroc Industries Limited at Drumbo which ships to its Mississauga wallboard plant. Production from Manitoba and from Windermere, Canal Flats (Lussier River) and Falkland in British Columbia supply the Prairie Region and most of the British Columbia markets. Production in New Brunswick is used locally to manufacture cement. Imports from Mexico and the United States are used by both wallboard and cement producers in British Columbia.

The portland cement industry requires up to 5% by weight of gypsum intimately ground with cement clinker to act as a set inhibitor. Amounts consumed may total more than 500 000 t/y in Canada.

CANADIAN DEVELOPMENTS

Gypsum production in Canada is in direct response to demand from the wallboard industries in Canada and the United States, which in turn serves the building construction sector relating to residential, institutional and commercial projects. In recent years, housing starts have become a less-than-accurate indicator of the demand for gypsum wallboard because improved fire retardant qualities, along with more renovation work, have encouraged broader use.

Domtar Inc. announced in August 1988 that it will construct a US\$35 million gypsum board plant in Newington, New Hampshire. Planned initial annual capacity is about 33 million m^2/y with eventual capacity to reach 50 million m^2/y. Start-up is planned for 1990; crude gypsum will be supplied from the company's Flat Bay (Newfoundland) mining operation, thus assuring an on-going major outlet for this material. In Ontario, Domtar is developing a new underground mine to supply its adjacent gypsum board complex at Caledonia. This facility supplies 70 million m^2/y of wallboard to construction and renovation markets in the United States and Canada. Development costs are estimated at \$13 million and full production is planned for 1990 when existing reserves are exhausted. New reserves at present levels of output are expected to be sufficient for 75 years. In Manitoba, Domtar began opening a quarry in Amaranth to replace depleting reserves at Gypsumville. In November the company closed its wallboard plant in Saskatoon, with regional markets in the area now being served mainly from Winnipeg.

CGC Inc., a diversified public company owned 75% by USG Corporation of Chicago, approved a \$7 million, 6-year project, initially to expand ore reserves at Hagersville. An expansion and modernization project at its Montreal wallboard plant was completed in 1988.

Louisiana-Pacific Corporation, of Portland, Oregon, announced that it will build a \$65 million fibre-gypsum board plant on Cape Breton Island. The plant will use recycled paper, local gypsum and imported perlite to produce about 22 million m^2/y of finished product beginning in 1990. Output

---

O. Vagt is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 992-2667.

will mainly go to construction markets in the northeast and mid-Atlantic states marking the first time that a finished board product of this type will be exported from Nova Scotia.

OCCURRENCES

Gypsum is a relatively low-cost, high-bulk mineral commodity generally produced from deposits situated as conveniently as possible to markets for related finished products. Exceptions occur if deposits of unusually high quality are available and if comparatively inexpensive mining methods are applicable, or if low-cost, high-bulk shipping facilities are accessible. Nova Scotia and Newfoundland deposits meet these criteria and have been operated for many years by, and for, United States companies in preference to some known but unexploited United States deposits.

Occurrences of gypsum other than those being exploited are known in the southwest lowlands west of the Long Range Mountains in Newfoundland; throughout the central and northern mainland of Nova Scotia as well as on Cape Breton Island; in the southeastern counties of New Brunswick; on the Magdalen Islands of Quebec; in the Moose River, James Bay and southwestern regions of Ontario; in Wood Buffalo National Park, in Jasper National Park, along the Peace River between Peace Point and Little Rapids, and north of Fort Fitzgerald in Alberta; on Featherstonhaugh Creek, near Mayook, at Canal Flats, and Loos in British Columbia; on the shores of Great Slave Lake, the Mackenzie, Great Bear and Slave rivers in the Northwest Territories; and on several Arctic islands.

WORLD DEVELOPMENTS AND TRADE

Gypsum occurs in relative abundance throughout the world, however with dependence on the building construction industry, developments are generally limited to the industrialized countries. Reserves are extremely large and are conservatively estimated at over 2.5 billion t. Canada is the world's second largest producer of natural gypsum after the United States, together accounting for about 26% of world output.

Gypsum products, particularly wallboard, have limited market range because of high unit weight, friability, high transportation costs and relatively low unit values. These factors generally dictate that markets be supplied by the nearest producer. There are exceptions however, and in addition to cross-border shipments between Canada and the United States, there have been shiploads of wallboard by European producers to ports in the southeastern United States. Imports into Canada and the United States from Mexico have increased. More recently, with strong demand, good prices, low production costs and competitive shipping arrangements, gypsum from Spain has become more important in North American markets. The Canada-United States trade is usually in truckload lots of 20 to 25 t for delivery to warehouses or to job sites. During recent years however, with strong demand extending the limits of trucking facilities, rail shipments have become common.

In the United States, Georgia-Pacific Corporation announced its intention to build a gypsum wallboard plant using synthetic gypsum provided by a Tennessee Valley Authority power plant. This particular project represents a new and unique technology, but is the company's eleventh wallboard plant in the United States. In 1987, a wallboard plant in east Texas became the first in North America to use synthetic gypsum to manufacture wallboard.

PROCESSING AND USES

Gypsum is a hydrous calcium sulphate ($CaSO_4.2H_2O$) which, when calcined at temperatures ranging from 120° to 205°C, releases three-quarters of its chemically combined water. The resulting hemihydrate of calcium sulphate, commonly referred to as plaster of paris, when mixed with water can be moulded, shaped or spread and subsequently dried, or set, to form a hard plaster. This is particularly suited to products including wallboard, lath and tile. Anhydrite, an anhydrous calcium sulphate ($CaSO_4$), is commonly associated geologically with gypsum but is not a suitable substitute for most uses.

The type of processing necessary depends upon end use. Crude gypsum is crushed, pulverized and calcined to form stucco, which may be mixed with water and aggregate (sand, vermiculite or expanded perlite) and applied over wood, metal or gypsum lath to form interior wall finishes. Gypsum wallboard, accounting for more than 70% of uses in North American markets, along with lath and sheathing, are formed by introducing a slurry of stucco, water, foam, pulp and starch between two unwinding rolls of absorbent paper resulting in a continuous "sandwich" of wet board. As the stucco hardens, the board is cut to predetermined lengths, dried, bundled and stacked for shipment. Gypsum for use in cement is crushed to -13 mm only. For agricultural or filler use it is dried and finely ground to about 100 mesh. Sheathing products may contain asphalt impregnated paper along with asphalt added to the gypsum core to improve water resistance.

In addition to its use in the manufacture of portland cement as a set regulator crude gypsum is used as a filler in paint and paper manufacture, as a substitute for salt cake (sodium sulphate) in glass manufacture and as a soil conditioner.

By-product gypsum produced by the acidulation of phosphate rock in phosphate fertilizer manufacture, has not been utilized in Canada despite available technology. In Europe and Japan however, by-product gypsum is used in the manufacture of gypsum products, by cement manufacturing plants, and also for soil stabilization. Recent experiments in France have produced paper with a 20% phosphogypsum content as filler. Studies have indicated that a potential radiation hazard exists in the use of phosphogypsum produced from sedimentary phosphate rock which can contain significant quantities of uranium and radium. Cooperative research programs have been conducted to determine the suitability of using waste fluorogypsum from Allied Chemicals Canada Inc.'s, Amherstburg, Ontario plant at St. Lawrence Cement Inc.'s Mississauga, Ontario cement plant.

The use of lime or limestone mainly to desulphurize stack gases from utility plants, industrial plants burning high-sulphur fuel, or from sulphide ore smelting plants, also results in the production of large amounts of waste gypsum in the form of a sludge presenting disposal problems. To further address the issue, ORTECH International, in November 1988, sponsored a seminar in Toronto on the utilization of by-product gypsum in North America. Representatives included the power and chemical industries, environmental regulatory agencies and other government bodies, equipment manufacturers and established gypsum producers.

Canadian Standards Association (CSA) Standards A 82.20 and A 82.35 relate to gypsum and gypsum products.

PRICES

Prices for gypsum in non-captive markets are negotiated; the only published figure being an approximate minimum price for crude material, ex-mine or c.i.f. United Kingdom, published in Industrial Minerals. Based on trends in the United States, prices for crude material, f.o.b. mine have fallen from US$8.70/t in 1983 to US$7.55/t in 1987. The availability of lower-priced gypsum from Mexico and Spain has resulted in lower prices in some parts of the world.

OUTLOOK

Canada's economic recovery slowed to an annual inflation-adjusted growth rate of 2.8% in the third quarter of 1988, down from 4% in the second quarter. Upward pressure on interest rates in the summer eased in October, however fears of inflation remain following 5 years of growth. Canadian business investment (machinery and equipment and non-residential construction) began to increase considerably starting in the last quarter of 1987. Housing starts, rose to 245 986 in 1987 and are expected to be about 220 000 in 1988. Indicators such as relatively stable interest rates, falling unemployment and moderate consumer prices suggest a positive outlook for the building construction sector. Nevertheless, housing starts in 1989 are expected to decline to a more sustainable level of 180 000-200 000 annually. The robust 5% expansion in Ontario is expected to slow in 1989 and lower residential construction in Quebec may result in some slowdown, according to projections in late 1988 by the Conference Board of Canada.

The Canadian Construction Association is predicting increases in the non-residential contract construction industry constant dollar expenditures of 4.5% between 1986 and 1995. The construction industry as a whole has expressed concern about the state of Canada's large infrastructure network. Adequate renovation programs earlier would dispel the need for comprehensive programs later and would allow the construction industry - and related portion of the mining industry - to plan five to ten years ahead with overall benefits in efficiency. The need for gypsum-based building products is expected to continue rising. Although new construction materials are being introduced, gypsum wallboard will remain popular because of its low price, ease of installation and well-recognized insulating and fire-retarding properties. The present structure of the industry in Canada is not expected to change greatly, although future availability of by-product gypsum based on satisfying stricter environmental controls will likely influence developments in some areas.

Both residential and commercial renovation work is expected to play a substantial role in the wallboard market, thus moderating major swings in demand.

ANHYDRITE

Production and trade statistics for anhydrite are included with gypsum statistics. Anhydrite is produced by Fundy Gypsum Company Limited at Wentworth, Nova Scotia, and by Little Narrows Gypsum Company Limited at Little Narrows, Nova Scotia.

According to the Nova Scotia Department of Mines and Energy, production of anhydrite in 1987 was 154 000 t and in 1988 was about 118 000 t. Most output was shipped to the United States for use in portland cement manufacture and as a peanut crop fertilizer. Cement plants in Quebec and Ontario also used some Nova Scotia anhydrite.

TARIFFS

Item No.	Description	Canada MFN	Canada GPT	Canada USA	United States Canada
2520.1000	- Gypsum; anhydrite	Free	Free	Free	Free
68.09	Articles of plaster or of a composition based on plaster				
	- Boards, sheets, panels, tiles and similar articles, not ornamented				
6809.11	-- Faced or reinforced with paper or paperboard only				
6809.11.10	--- Gypsum wallboard	9.4%	Free	8.4%	2.1%
6809.11.90	--- Other	9.2%	Free	8.2%	2.1%
6809.19	-- Other	10.2%	6%	9.1%	5.4%
6809.90	- Other articles				
6809.90.10	--- Models and casts, of a kind used in the manufacture of dental prostheses	Free	Free	Free	3.8%
6809.90.90	--- Other	10.2%	6.5%	9.1%	3.8%

Sources: Customs Tariffs, effective January 1989, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States (First Edition Supplement 2) effective January 1, 1989.

TABLE 1A. CANADA, GYPSUM PRODUCTION AND TRADE, 1986 AND 1987

	1986		1987	
	(tonnes)	($000)	(tonnes)	($000)
Production (shipments)				
Crude gypsum				
Nova Scotia	6 263 988	50 126	6 274 142	53 479
Ontario	1 321 457	16 974	1 468 215	16 547
Manitoba	246 505	5 039	379 759	6 060
British Columbia	485 279	4 896	535 659	5 529
Newfoundland	485 576	6 038	x	5 338
New Brunswick	-	-	x	32
Total[1]	8 802 805	83 073	9 093 926	86 984
Imports				
Crude gypsum				
Mexico	101 376	3 268	118 460	3 676
Spain	87 393	705	83 327	735
United States	32 775	649	15 675	404
Hong Kong	100	3	161	3
Total	221 644	4 625	217 623	4 818
Plaster of paris and wall plaster				
United States	21 294	5 154	25 795	5 170
West Germany	-	-	100	28
Japan	10	2	2	1
Hong Kong	3	1	-	-
Total	21 307	5 157	25 897	5 199
	(square metres)		(square metres)	
Gypsum lath, wallboard and basic products				
United States	1 696 814	2 902	6 452 926	11 609
Other countries	94 206	154	74 475	112
Total	1 791 020	3 056	6 527 401	11 721
Total imports gypsum and gypsum products		12 838		21 738
	(tonnes)		(tonnes)	
Exports				
Crude gypsum				
United States	5 921 961	51 832	5 704 670	49 620
Other countries	21	3	189	84
Total	5 921 982	51 835	5 704 859	49 704
	(square metres)		(square metres)	
Gypsum lath, wallboard and basic products				
United States	76 523 724	134 938	72 542 905	108 669
Bermuda	61 837	102	26 753	57
Trinidad and Tobago	9 637	46	5 886	39
Algeria	29 438	71	15 655	28
Other countries	65 400	99	25 513	37
Total	76 690 036	135 256	72 616 712	108 830
Total exports of gypsum and gypsum products	..	187 091	..	158 534

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Totals do not include gypsum produced by or shipped for use by Canadian portland cement producers.

- Nil; x Confidential; .. Not available.

Note: Totals may not add due to rounding.

TABLE 1B. CANADA, GYPSUM PRODUCTION AND TRADE 1988P

Item No.		1988P	
		(tonnes)	($000)
Production (shipments)			
	Crude gypsum		
	Nova Scotia	6 330 724	58 243
	Ontario	1 458 800	19 712
	British Columbia	428 450	4 970
	Manitoba	x	3 655
	Newfoundland	x	1 075
	New Brunswick	x	19
	Total[1]	8 521 749	87 674
		(Jan.-Sept.)	
Imports			
2520.1000	Gypsum; anhydrite		
	Mexico	66 390	2 157
	Spain	77 819	692
	United States	41 283	1 261
	Other countries	170	4
	Total	185 662	4 114
		(square metres)	
6809.11	Plaster boards etc. not ornamental; faced or reinforced with paper or paperboard		
	United States	13 306 385	15 017
	Other countries	47 022	96
	Total	13 353 407	15 113
6809.19	Plaster boards etc. not ornamental; faced or reinforced with paper or paperboard n.e.s.		
	United States	..	393
	Other countries	..	60
	Total	..	453
6809.90	Articles of plaster or composition based on plaster n.e.s.		
	United States	..	618
	Italy	..	245
	United Kingdom	..	95
	Other countries	..	22
	Total	..	980
Total imports of gypsum and gypsum products		..	20 660
Exports			
2520.1000	Gypsum; anhydrite		
	United States	4 044 395	38 018
	Other countries	36 244	655
	Total[1]	4 080 639	38 673
6809.11	Plaster boards etc. not ornamental; faced or reinforced with paper or paperboard		
	United States	..	67 609
	Other countries	..	157
	Total	..	67 766

TABLE 1B. CANADA, GYPSUM PRODUCTION AND TRADE 1988P (cont'd)

Item No.		1988P Jan.-Sept. (tonnes)	1988P Jan.-Sept. ($000)
6809.19	Plaster boards etc. not ornamental; faced or reinforced n.e.s.		
	United States	..	4 969
	Other countries	..	126
	Total	..	5 095
6809.90	Articles of plaster or compositions based on plaster		
	United States	..	669
	United Kingdom	..	125
	Other countries	..	56
	Total	..	850
Total exports of gypsum and gypsum products		..	112 384

Sources: Energy Mines and Resources Canada; Statistics Canada.

[1] Totals do not include gypsum produced by or shipped for use by Canadian portland cement producers.

P Preliminary; x Confidential; .. Not available; n.e.s. Not elsewhere specified.

TABLE 2. CANADA, GYPSUM MINING AND GYPSUM PRODUCTS MANUFACTURING OPERATIONS, 1988

Company	Location	Operation
Newfoundland		
Domtar Inc.[1]	Flat Bay	Open-pit mining - reopened in May 1988
Atlantic Gypsum Limited	Corner Brook	Wallboard manufacture
Nova Scotia		
Domtar Inc.	McKay Settlement	Open-pit mining of gypsum by contract
	Windsor	Plaster and "Gypcrete" manufacture
Fundy Gypsum Company Limited	Wentworth and Miller Creek	Open-pit mining of gypsum and anhydrite
Georgia-Pacific Corporation	River Denys, Sugar Camp	Open-pit mining of gypsum
Little Narrows Gypsum Company Limited	Little Narrows	Open-pit mining of gypsum and anhydrite
National Gypsum (Canada) Ltd.	Milford	Open-pit mining of gypsum
New Brunswick		
Lafarge Canada Inc.	Havelock	Open-pit mining of gypsum for cement manufacture
Quebec		
CGC Inc.	Montreal	Wallboard manufacture
	St-Jerome	Wallboard manufacture
Domtar Inc.	Montreal	Wallboard plant now used only as distribution terminal
Westroc Industries Limited	Ste. Catherine d'Alexandrie	Wallboard manufacture
Ontario		
CGC Inc.	Hagersville	Underground mining and wallboard manufacture
Domtar Inc.	Caledonia	Underground mining and wallboard manufacture
Westroc Industries Limited	Drumbo	Underground mining
	Clarkson	Wallboard manufacture
Manitoba		
Domtar Inc.	Gypsumville	Open-pit mining
	Winnipeg	Wallboard manufacture
Westroc Industries Limited	Amaranth	Open-pit mining
	Winnipeg	Wallboard manufacture
Saskatchewan		
Domtar Inc.	Saskatoon[1]	Closed wallboard manufacturing plant in November.
Alberta		
Domtar Inc.	Calgary	Wallboard and "Gypcrete" manufacture
	Edmonton[1]	Wallboard manufacture
Westroc Industries Limited	Calgary	Wallboard manufacture
British Columbia		
Domtar Inc.	Canal Flats	Open-pit mining
	Vancouver	Gypsum products manufacture
Westroc Industries Limited	Vancouver[2]	Gypsum products manufacture
	Windermere	Open-pit mining
	Vancouver[3]	Gypsum products manufacture

---

[1] Genstar Corporation affiliated operation acquired by Domtar Inc. in June 1985. [2] Genstar plant in Vancouver acquired by Westroc Industries Limited in June 1985. [3] Westroc Industries Limited Vancouver plant closed in June 1985.

TABLE 3. CANADA, GYPSUM PRODUCTION, TRADE AND CONSUMPTION, 1975, 1979-87

	Production[1]	Imports[2]	Exports	Apparent Consumption[3]
		(tonnes)		
1975	5 719 451	55 338	3 691 676	2 083 113
1979	8 098 166	152 953	5 474 765	2 776 354
1980	7 336 000	154 717	4 960 240	2 530 477
1981	7 025 000	143 500	5 094 873	2 073 627
1982	5 987 000	93 843	4 775 755	1 305 088
1983	7 507 000	100 939	5 187 032	2 420 907
1984	7 775 082	131 809	6 224 574	1 682 317
1985	7 760 783r	121 802	5 879 664r	2 002 921r
1986	8 802 805	221 644	5 921 982r	3 102 467r
1987	9 093 926	217 623	5 704 859	3 606 690

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Producers' shipments, crude gypsum. [2] Includes crude and ground, but not calcined.

[3] Production plus imports minus exports.

r Revised.

TABLE 4. CANADA, HOUSE CONSTRUCTION, BY PROVINCE, 1986 AND 1987

	Starts			Completions			Under Construction		
	1986	1987	% Diff.	1986	1987	% Diff.	1986	1987	% Diff.
Newfoundland	2 883	2 682	-7.0	2 400	2 836	18.2	3 823	3 631	-5.0
Prince Edward Island	1 110	933	-16.0	1 176	943	-19.8	362	338	-6.6
Nova Scotia	7 571	6 460	-14.7	7 571	6 488	-14.3	3 435	3 283	-4.4
New Brunswick	4 045	3 716	-8.1	4 504	3 944	-12.4	1 770	1 524	-13.9
Total (Atlantic Provinces)	15 609	13 791	-11.6	15 651	14 211	-9.2	9 390	8 776	-6.5
Quebec	60 348	74 179	22.9	56 984	68 949	21.0	24 531	28 974	18.1
Ontario	81 470	105 213	29.1	69 567	88 609	27.4	48 625	64 458	32.6
Manitoba	7 699	8 174	6.2	7 341	7 627	3.9	4 178	4 765	14.0
Saskatchewan	5 510	4 895	-11.2	5 072	5 640	11.2	3 255	2 457	-24.5
Alberta	8 462	10 790	27.5	9 172	9 334	1.8	2 913	4 331	48.7
Total (Prairie Provinces)	21 671	23 859	10.1	21 585	22 601	4.7	10 346	11 553	11.7
British Columbia	20 687	28 944	39.9	20 818	23 606	13.4	8 548	13 986	63.6
Total Canada	199 785	245 986	23.1	184 605	217 976	18.1	101 440	127 747	25.9

Source: Canada Mortgage and Housing Corporation.

TABLE 5. CANADA, VALUE OF CONSTRUCTION[1] BY TYPE, 1986-88

	1986	1987	1988
		($ millions)	
Building Construction			
Residential	28 885	36 003	35 651
Industrial	3 201	3 189	3 339
Commercial	10 119	12 068	13 097
Institutional	3 565	4 172	4 202
Other building	1 656	1 796	1 987
Total	47 427	57 228	58 277
Engineering Construction			
Marine	335	361	489
Highways, airport runways	5 192	5 065	5 284
Waterworks, sewage systems	2 377	2 294	2 553
Dams, irrigation	243	248	287
Electric power	3 370	3 625	4 443
Railway, telephones	2 753	2 954	3 024
Gas and oil facilities	6 728	5 917	7 490
Other engineering	3 275	3 164	3 432
Total	24 274	23 628	27 002
Total construction	71 701	80 856	85 279

Source: Statistics Canada.
[1] Actual expenditures 1986, preliminary actual 1987, intentions 1988.

TABLE 6. WORLD PRODUCTION OF GYPSUM, 1987 AND 1988

	1987	1988[e]
	(000 tonnes)	
United States	14 163	12 701
Canada	9 094	8 522
Japan	6 532	6 804
France	4 508	4 536
Spain	5 534	5 534
People's Republic of China	7 167	7 257
U.S.S.R.	4 990	4 990
Iran	8 437	8 165
United Kingdom	3 202	3 175
Mexico	2 457	2 722
West Germany	1 905	1 905
Other market economy countries	17 389	17 599
Other central economy countries	4 625	4 581
World total	90 003	88 491

Sources: Energy, Mines and Resources Canada; U.S. Bureau of Mines Mineral Commodity Summaries, January 1988.
[e] Estimated.

Indium

G. COUTURIER

Indium metal is recovered as a minor by-product during zinc and lead-zinc smelting and refining. As the world's largest producer and exporter of zinc and zinc concentrates, it is likely that Canada is also the world's major source of indium, though statistics to confirm this are lacking. Zinc ores are not assayed for their indium content, nor do zinc plants determine indium contents of their feedstock. Indium is extracted from the residues and dusts recovered during the refining process, as well as from drosses, slags and anode slimes during the refining of lead bullion and crude zinc. Indium-bearing dross or fume can be treated by pyrometallurgical/electrolytic or chemical means until purities of 99.97% indium or higher are obtained.

DOMESTIC

Indium has been recovered in Canada since 1952 at the zinc-lead metallurgical operations of Cominco Ltd. at Trail, British Columbia. In October 1988, Cominco sold its Electronic Materials Division to Johnson Matthey Public Limited Company of the United Kingdom for $40 million. Canadian regulatory authorities approved the sale in December 1988. Included in the sale were Cominco's rare metals production plants at Trail, British Columbia, which provides electronic grade metals at a purity above 4N, and its research facilities at Victoria, British Columbia, and at Spokane, Washington. Johnson Matthey's production capacity of indium at the 6N purity level from its new Trail facilities was reported to be around one tonne for 1988.

Cominco had unveiled its plans in February 1988, to build a $2.3 million indium plant and a $5.8 million germanium plant at its Trail complex. When the new indium plant becomes fully operational in mid-1989, its current 10 t/y production capacity will triple to 30 t/y. However, actual production will be tailored to market conditions. Indium will be extracted both from processing wastes stockpiled at Trail over the years, and from concentrates produced at Cominco's Sullivan mine. For this new plant, Cominco had developed a new process which improved indium recovery at a much lower cost. Cominco's new Red Dog mine in Alaska is not expected to become a major feed source for the new plant because the deposit is low in indium content.

In 1988, Falconbridge Limited completed pilot-plant testing and basic engineering work on a 30 t/y indium recovery plant for its Kidd Creek complex at Timmins, Ontario, but deferred the construction decision to 1989. Production of indium was envisaged at a 4N purity level which could be sold on the world markets. A portion of the 4N indium would be further refined to electronic grades at the plant of Indium Corp. of America in Utica, New York.

With the expansion of the Trail facility and the possibility of a new indium recovery plant at Timmins, Canada could become the world's largest indium producer, with a production capacity of around 60 t/y compared to current world production in the neighbourhood of 150 t/y.

On the Canadian R&D front, Bell Northern Research Inc., of Nepean, Ontario, is currently conducting a research program on the use of indium phosphide in semiconductors and advanced laser technology.

WORLD

The United States remains the world's largest producer of refined indium. Production of about 25 t/y in purities up to 7N comes mainly from two operations: Indium Corp. of America's plant at Utica, New York and Arconium Corp. of America's plant at Providence, Rhode Island. In light of attractive market opportunities that include upgrading of some of the 4N indium from the proposed Falconbridge recovery plant, Indium Corp. has decided to invest in a new

---

G. Couturier is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 992-3784.

refinery that will produce indium metal, high-purity indium and indium organometallic compounds.

Arconium Corp. of America, is mainly involved in the refining of high purity indium.

The decision by the U.S. government to consider the acquisition of significant quantities of indium for its National Defense Stockpile, if implemented, could trigger a marked increase in demand for indium.

Two strikes at Empresa Minera del Centro del Peru S.A.'s (Centromin-Peru S.A.) anodic slimes plant in Peru halted indium production for about three months in 1988 (from mid-July to mid-August and from mid-October to mid-December). This plant produces about 4 t/y indium as a by-product of zinc refining. While some loss of output was reported, production was believed to be at normal levels by the end of December.

In Europe, the 1988 merger of France's Société minière et métallurgique de Penarroya S.A. (Penarroya) with West Germany's Preussag AG created a new company called Metaleurop SA. Penarroya's indium production facilities in France and Italy totalled 19 t/y while Preussag's production was estimated at 1 t/y. The merger is viewed as a good marriage as it combines Penarroya's extensive sources of raw materials with Preussag's know-how in the field of downstream and high-purity products.

Several European and North American indium producers have expressed interest in forming an Indium Institute, which would operate jointly with the existing Bismuth Institute headquartered in Brussels. A decision on the creation of an Indium Institute is expected sometime in 1989.

Japan was estimated to have produced some 30 t of indium in 1988. Production was dominated by Nippon Mining Company Limited which accounted for an estimated 18 t, followed by Sumitomo Metal Mining Co. Ltd., at an estimated 3 t, with Mitsui Mining & Smelting Co. Ltd. and Dowa Mining Co., Ltd. making up the remainder. However, it is reported that Japanese indium producers will not be able to sustain the 30 t/y production level because of expected decreases in refined zinc production and exhaustion of indium-rich residues from which the metal was recovered.

CONSUMPTION AND MARKETS

Indium is a silver-white metal that resembles tin in its physical and chemical properties. Its chief characteristics are its high malleability and ductility at room temperature, its low melting point (156°C) and high boiling point (2080°C). Its density at 20°C is 7.31, which is about the same as iron. Indium does not oxidize in air at ordinary temperatures but will react readily at high temperatures or in solution. It has a relatively low electrical resistivity and an ability to absorb neutron radiation.

Detailed statistics on consumption and production for indium are not available. Estimates of western world indium consumption vary between 90 to 100 t/y, and production is estimated to be between 80 t/y to 100 t/y. The People's Republic of China, and to a lesser extent the U.S.S.R., are sporadic exporters of indium metal to the western world.

Indium is used in the following applications: semiconductors and electronics, accounting for 25% of total consumption; solders, low-melt alloys and fusible alloys, 15%; light-crystal displays, light-emitting diodes and other display devices, 15%; nuclear-control rods, 13%; batteries, 10%; bearing coatings, 8%; dental alloys, 6%; and miscellaneous, 8%.

Indium's use as a window de-mister appears to be the most promising growth area. The Japanese automotive industry is reported to be using significant amounts of indium-tin oxide, which has been used for more than two decades to prevent icing and fogging in windshields for aircraft as well as in high-speed trains.

Japanese demand for indium, now estimated at 60 t/y, is reported to be growing rapidly, in excess of 20% annually since the 1986 level of 40 t/y. End uses of indium in Japan are mostly for transparent electrodes, 16 t (27%); fluorescents, 12 t (20%); and semiconductors, 8 t (13%).

Through the development of a semiconductor material known as copper-indium-diselenide, which converts sunlight into electricity, U.S. scientists have been able to increase the efficiency of solar panels from 8% to over 11%. This breakthrough could provide a new market for indium, as at an efficiency rate of 15%, solar panels could become economically feasible alternatives to conventional energy sources.

PRICES AND OUTLOOK

Indium prices over the past ten years, have been extremely volatile. These wide price fluctuations have hurt indium and hampered development of new applications for the metal. For example, Indium Corp. of America's published indium price for standard grade 4N material ranged from US$346 to US$643/kg in 1979/80 as compared to US$80 to US$92/kg in 1985/86.

More recently, indium prices for the premium priced 4N material decreased from a peak level of US$350/kg in 1987 to a low of around US$240/kg in 1988, recovering to around US$300/kg at year-end. Price fluctuations in 1988 were prompted in part by Cominco's announcement of tripling its production capacity and by Falconbridge's work on a possible 30 t/y indium plant. Moreover, London minor metals traders were reported to be considering pursuing actions against Chinese producers for delinquent deliveries of indium, which also adversely effected price stability of the metal.

If both Canadian projects were to come on-stream at full capacity, increasing world production by some 50%, the supply-demand equilibrium for indium could be jeopardized for the short-term. On the other hand, more abundant supplies of indium from efficient producers could substantially improve the industry's long-term prospects by securing supplies and stabilizing long-term prices, leading to increased interest in developing new applications for the metal. Currently, new applications for indium are not always being aggressively pursued because of price and supply instability.

Under an optimistic scenario, the outlook for indium is that prices could settle at around the US$200/kg level. However, present indium smelter capacity exceeds production by a factor of two and raw materials are readily available. Given this situation and the projected indium demand growth rate, consumption may only reach production capacity in 1995. Clearly, indium pricing under such conditions, in the interim, is uncertain at best.

Item No.	Description	Canada			United States	EEC	Japan[1]
		MFN	GPT	USA	Canada	MFN	MFN
8112.91.10.30	-----Indium	4%	Free	3.2%	Free	3.5%	3.7%
8112.91.20	---Unwrought metal, alloyed; waste and scrap; powders, alloyed	10.2%	6.5%	8.1%	Free	3.5%	5.1%
8112.91.20.13	------Indium	10.2%	6.5%	8.1%	Free	3.5%	5.1%
8112.99	--Other						
8112.99.90	---Other	10.2%	6.5%	8.1%	Free	3.8%	6.5%
8112.99.90.30	-----Indium	10.2%	6.5%	8.1%	Free	3.8%	6.5%

Sources: Customs Tariffs, effective January 1989, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States (First Edition, Supplement 2) effective January 1, 1989; Official Journal of the European Communities, Vol. 30, No. L256, 1987, "Conventional" column; Custom Tariff Schedules of Japan, 1988.

[1] GATT rate is shown, lower tariff rates may apply circumstantially.

Iron Ore

B.W. BOYD

World production, consumption and trade in iron ore increased again in 1988. The previous year's production was 938 Mt, and trade was 367.8 Mt. The critical segment of the market for Canada, iron ore pellets, tightened toward year-end 1987, and the market held, so that pellet plants operated at capacity in 1988. The steel industries in North America and western Europe began to recover, and trade for iron ore shifted back to the patterns established prior to the recession of 1982.

The world price of iron ore pellets began to recover in 1987, although the prices for concentrates (fines) and lumps remained soft. A further problem for Canadian producers was a trend to sell larger proportions of their production at the world price each year, and smaller proportions at the higher 'Lake Erie' price. The effect on Canadian iron ore mines in 1987 was an average revenue of $37.02 per tonne (revised), and a drop to $35.83 per tonne, in 1988.

The Canadian iron ore industry recovered to a relatively high operating level at the end of 1987. One of the mines and all of the pellet plants were able to operate at capacity during 1988.

CANADIAN DEVELOPMENTS

Six iron ore mines were again operating in Canada in 1988. Production capacity remained unchanged at 49 Mt. Production was estimated at 39.8 Mt, representing 80% of capacity. Canadian shipments of iron ore increased 2.3 Mt to 40.7 Mt, including shipments from stockpiles. The total value was $1 400 million.

Employment at Canadian iron ore mines, concentrators, agglomerating plants and support services remained at about 6500 during the last two years as compared with a peak of 17 000, in 1976.

Exports exceeded 30 Mt and, as in the past several years, western Europe was the largest market for Canadian ore. Exports to the United States exceeded 9 Mt, up about 20% over 1987.

Among individual companies, Iron Ore Company of Canada (IOC) shipped 14.8 Mt of iron ore of which 7.9 Mt were acid pellets, 2.0 Mt were fluxed pellets, 4.1 Mt were concentrate and 0.8 Mt were blended Schefferville ores and Carol Lake concentrates. The Schefferville ore was shipped from the stockpile at Sept-Îles, Quebec, but, for purposes of National Accounts, had been taken as production in 1984, the last year the mine at Schefferville operated. This has created a discrepancy between Tables 1 and 2. Other differences are due to the use of dry weight in the National Accounts (Table 1), and natural weight in Table 2.

At year-end, IOC's stockpile of direct-shipping ore from Schefferville stood at 200 000 t. It will be eliminated in 1989. Without the stockpile, IOC has available space at its dock and terminal at Sept-Îles. In October 1988, the facilities were used for coal transshipment and IOC is looking to increase use of the terminal for coal and other commodities.

Under a one year $897 300 joint venture announced in March, the Canada Centre for Mineral and Energy Technology (CANMET), will transfer its flotation recovery technology to work in conjunction with IOC's magnetic separation methods. The combination of technologies will improve iron ore recovery from fine ore. In-plant testing in 1988 is expected to lead to modifications in IOC's plant in 1989.

Quebec Cartier Mining Company (QCM) sold about 16.8 Mt of pellets and concentrate in 1988. Total production for the year was shipped as well as all beginning-of-the-year inventories which were already extremely low. The company continues to produce a

---

B.W. Boyd is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 992-8179.

wide variety of products, many of which are tailored to customer specifications. Pellet plant production exceeded 8.0 Mt in 1988, a record production level. Principal grades of pellets were acid, low-silica and self-fluxed. QCM also produced lesser quantities of low-titanium and low-silica self-fluxed pellets. In addition to its regular concentrate, QCM produced high siliceous, low-titanium and low-phosphorus concentrates. Production was sustained over a twelve-month period.

Production at Wabush Mines for the year was over 6 Mt, representing full capacity. The company mined two grades of ore, based on manganese (Mn) content, in separate levels of Wabush's Scully mine in Labrador. Wabush continued its program to improve marketability of its ore by offering three products in 1988, acid pellets with 1.0% Mn; fluxed pellets with 1.0% Mn; and acid pellets with 2.0% Mn. The lower manganese fluxed pellets were produced for Stelco Inc. and Dofasco Inc. steel mills in Hamilton, Ontario. The increase from one to three products has required Wabush to install a new stacker/reclaimer at its terminal at Pointe Noire, Quebec.

Wabush is facing a major expense on pollution control equipment over the next few years. The Quebec Minister of the Environment has stated that Wabush would not be granted further extensions to the time limit for bringing dust emissions from the pellet plant under control. The projected cost for the necessary electrostatic precipitator system is $40 million.

The Algoma Ore Division (AOD) of The Algoma Steel Corporation, Limited had a relatively good year. A major restructuring in 1986 to reduced the nominal annual production capacity to 900 000 t of super-fluxed sinter, but, in 1988, AOD was able to produce over 1 Mt.

Algoma's major investment in iron ore at present is the Magnetite Project at the Tilden mine in Michigan. Ownership in the Magnetite Project is 50% Algoma, 16.6% Stelco Coal Company and 33.4% Cleveland-Cliffs Inc. The estimated US$25 million cost will be shared accordingly. The mine will run nine months on magnetite and three months on hematite to produce 2.6 Mt of hematite pellets and 4 Mt of magnetite pellets for a capacity of 6.6 Mt total from 1989 onward. The magnetite orebody, Cliffs Drive 3, has a 14 year life at 4 Mt/y magnetite pellets, so that Algoma will get 2 Mt/y of the magnetite pellets plus a share of the hematite pellets. Tilden is on schedule, to begin May 1, 1989, for producing from magnetite. The magnetite ore has 0.018% phosphorus whereas the hematite has 0.035%. Use by Algoma will therefore require some trade-off of hematite pellets to keep phosphorus under control.

In 1988, Algoma took 2.4 Mt of pellets from Tilden. Dofasco Inc.'s two iron ore mines in northern Ontario, the Adams and Sherman, suffered strikes in 1988. At Adams the strike lasted four weeks and at Sherman five weeks. In addition, the Adams concentrator and mine closed for five weeks in July but the pellet plant operated all summer. The Sherman mine shut down all operations for five weeks in the summer. As a result, production at Adams was below 1 Mt and at Sherman it was below 0.9 Mt.

As of April 29, 1988 the Adams mine produced its 25 millionth tonne of pellets. Reserves are good for another 15 years.

All of Dofasco's mine product was fluxed pellets containing limestone and dolomite from Ontario quarries. Dofasco is totally committed to fluxed pellets, primarily because it has obtained excellent results on material savings as well as higher efficiency in the blast furnaces.

At the Adams mine, organic binders were tested as substitutes for bentonite from Wyoming. Reasonable success was gained with 0.3 lb. of Alkatack, from Allied Colloids Inc., in each tonne of pellets. The pellets were stronger, sized more uniformly and had lower silica than those made with straight bentonite.

WORLD DEVELOPMENTS

Some 53% of Canadian iron ore production is marketed outside North America. Canada accounts for about 4% of world iron ore production, and about 8% of international iron ore trade. Brazil, Australia and the U.S.S.R. export more iron ore than does Canada. India and Canada have similar exports, about 30 Mt/y.

Increased steel production worldwide has temporarily relieved the glut in the iron ore market and stalled the decline in iron ore prices suffered over the past five years.

Production of steel in the European Economic Community was up by 8% for the first nine months of 1988 relative to the same period in 1987. Consequently Brazil, Canada and Australia, the principal suppliers of iron ore to Europe's steel industries, were able to increase shipments. Total 1988 imports by the EEC are estimated to have exceeded the 130 Mt taken in 1987.

United States crude steel production for the first nine months of 1988 was up 16.5% over the previous year; receipts of iron ore at the steel plants were up by 25% for the first 10 months. For the full year, 1988, deliveries of iron ore to U.S. steel plants were estimated at 68 Mt, of which 73% came from domestic mines, 13% came from Canada and 14% from offshore.

The U.S. iron ore industry enjoyed a significant recovery with the improved steel industry performance, but imports from offshore increased by 37%, and may become an even more important factor in iron ore supply to the U.S. steel industry. A private study for the Port of Quebec is reported to have indicated that increasing demand for Brazilian iron ore by the U.S. steel industry could justify installation of $10 million in new bulk material handling equipment at the port to improve its transshipment capabilities.

Reserves of 'natural ore', otherwise known as direct shipping ore, in the United States' last natural ore mine, McKinley Extension, will be exhausted in 1993 if mining continues at the current rate. Natural ore was the basis for development of iron ore mining in Minnesota before the turn of the century, and provided the raw material for most iron and steel produced in the United States until development of taconites, in the mid-1960s.

In Japan, crude steel production increased by 9.6% for the first nine months of the year, totally attributed to increased domestic demand for steel products. The stronger market has prompted Australian iron ore producers to seek significant price increases in the negotiations for shipments in 1989.

For 10 months of 1988, Australia, Brazil and India supplied respectively, 46%, 22% and 20% of iron ore shipped to Japan, which is the largest importer of iron ore in the world. Japan's imports are estimated to have exceeded 111 Mt. Canada's share of the market, all from IOC's Carol Lake mine, amounted to 1.6%.

Nippon Kokan KK (NKK) of Japan opened a new pelletizing facility at the Fukuyama Works, in November. The plant uses a new process to produce "hybrid pelletized sinter" (hps) which is purported to have the advantages of both iron ore pellets and sinter yet be more economical than either. The process is reportedly capable of using various sizes and grades of iron ores and to produce a uniform product of sintered pellets in clusters like bunches of grapes. These clusters perform well in the blast furnace.

Steel production in Brazil showed a 14% increase in 1988 over the previous year. The continued growth of the steel sector is a moderating factor in the expansion of Brazil's role in world iron ore trade since much of the increase in ore production is taken by the domestic steel industry.

Brazil, at 140 Mt, was the third largest iron ore producer in the world, after the Union of Soviet Socialist Republics and the People's Republic of China. Brazil was the world's largest exporter, surpassing Australia for the fifth year in a row. Brazilian exports of iron ore were estimated to total 100 Mt in 1988 compared to 97.3 Mt in 1987.

Companhia Vale do Rio Doce (CVRD) in Brazil increased production from its Carajas mine to about 30 Mt in 1988. Late in the year, a bucket-wheel reclaimer at Ponta da Madiera, the port serving Carajas, collapsed and caused the death of four people. The accident has temporarily reduced the terminal's capacity by 25% and may cause a 5 Mt shortfall in shipments before repairs are completed in an estimated six months.

Minerações Brasileiras Reunidas SA (MBR) pursued plans to expand production capacity and exports through new investment at its mine at Mutuca, and in shipping and storage facilities in Minas Gerais State.

A new Brazilian railroad connecting Sepetiba Bay with MBR's iron ore deposits at Minas Gerais, which was begun 11 years ago and then abandoned, moved closer to completion during the year as construction resumed with financing from MBR's major shareholder and BNDES Participaçoes SA, the national development bank. According to one report, the railway may begin operations in 1989.

SA Mineraçao da Trindade (Samitri) has undertaken to invest US$50 million to expand ore production at its mine in Minas Gerais State and supply concentrate to Samarco Mineraçao SA for production of iron ore pellets. The proposed increase in export of fines and pellets is some 2 Mt.

In Australia, production for the 12 months up to June 1988, totalled 102.8 Mt and exports reached 88.5 Mt. Exports are forecast to increase a further 13% in fiscal 1988/89, to 100 Mt.

Construction at three projects was to begin in Western Australia during 1988. Under the agreement reached in 1987, to develop the Brockman deposit in the Channar Mining area of Australia, Hamersley Iron Pty., Ltd. and China Metallurgical Import and Export Corporation (CMIEC) began construction at the mine site. Initial production at about 3 Mt/y is scheduled for 1990, with gradual buildup to a maximum of 9 Mt/y. Hancock Prospecting Pty. Ltd. and BHP Minerals Ltd.'s Mt. Newman project were to develop the McCamey's Monster orebody in response to signing, in 1987, of an agreement with Romania to supply 53 Mt of iron ore over 15 years. The quantity under the agreement has been increased by 15 Mt with deliveries to be scaled up beginning in the fourth year.

Mt. Newman Mining Co. Pty. Ltd. and NKK reached agreement on the sale of 1.8 Mt/y of ore from the Marra Mamba mine for four years. The new pelletizing facility constructed by NKK, at Fukuyama, was designed to use Marra Mamba ore as well as ore from other sources.

India continued as a major supplier of iron ore in southeast Asia, but also pursued a policy to increase sales in Europe. In 1988, India resumed production of iron ore pellets, with commissioning of the 3 Mt/y pellet plant of Kudremukh Iron Ore Co. Ltd., in Karnataka State. The pellets are partially self-fluxed with a hydrated lime binder and are sold to steel mills in Yugoslavia, Hungary and Czechoslovakia.

The Chilean iron ore industry has diversified its market in the last five years. In 1983, Compania Minera del Pacifico S.A. (CMP) had only one export destination, Japan; in 1988, CMP shipped to Japan, Federal Republic of Germany, France, United States, Mexico, Qatar, People's Republic of China, Republic of Korea and Argentina. The success of Chile's iron ore producers can be gauged by the increase in capacity utilization, from 60% in 1987 to 90% in 1988.

CVG Ferrominera Orinoco C.A. of Venezuela, plans to invest in an expansion of its mine and construction of a 2 Mt/y pellet plant. Venezuela has consistently increased exports over the past five years, and is likely to recover to the pre-1982 levels in the next two years.

Argentina and Brazil plan to invest a total of $150 to $200 million in a joint venture pelletizing plant, in Patagonia, Argentina. The plant will use Brazilian iron ore and Argentinian natural gas.

In Peru, iron ore mining and especially pellet production suffered from strikes. After producing at over 9 Mt/y in the early 1970s, Peru's iron ore production had dropped to 4 Mt in 1984. The strikes were a severe blow at a time when the industry could have taken advantage of the buoyant iron ore pellet market in the Republic of Korea and in Japan.

The People's Republic of China (PRC) has been expanding its iron ore production capacity as part of an ambitious program to increase steel production. In 1987, iron ore production was a record 157 Mt and the PRC plans to increase production to 270 Mt in the year 2000. For the near future, however, PRC will be obliged to increase iron ore imports to feed its rapidly growing steel sector.

The Association of Iron Ore Exporting Countries (APEF) was formed, in 1975, to promote close cooperation among member countries, with a view to safeguarding their interests in relation to the iron ore export industry. Over the years, it developed a valuable information service, and the best compilation of world iron ore statistics available. However, the 26th Session of the APEF Board in 1988, decided to terminate the organization at the end of March 1989. Concern within the private sector and interested governments over the potential loss of APEF statistics brought together a number of member and non-member countries to try to preserve the secretariat's statistical service until an alternative solution can be found. An informal meeting, in October, led to conditional support from a number of countries for a proposal to establish a trust fund, under the administration of the United Nations Conference on Trade and Development (UNCTAD), to finance a continuation of the APEF statistical service until at least December 1990.

Commitments for support of the trust fund are expected early in 1989.

UNCTAD DIALOGUE ON IRON ORE

Since 1976, UNCTAD has sponsored four preparatory meetings on iron ore to determine suitable actions to stabilize iron ore trade. At the fourth meeting, it was agreed to establish an Intergovernmental Group of Experts on Iron Ore (IGE) with a mandate to review market developments in iron ore, and to report thereon to the Fifth Preparatory Meeting.

The first session of the IGE made considerable progress in developing a new statistical questionnaire and in exposing many problems and issues in the iron ore industry. The second session took place in March 1988 and attracted most major producer and consumer countries. This session dealt mainly with the questionnaire for member countries that the group has been developing to improve UNCTAD statistics on iron ore. However, the IGE was unable to reach agreement on whether iron and steel data could be included in the questionnaire and on future work of the UNCTAD secretariat on iron ore. Consequently, sufficient unfinished work remained that the delegates decided to schedule a third session of the IGE for the autumn of 1989.

PRICES

Western Europe and Japan each take about one-third of the iron ore that is traded internationally. Buyers in Europe normally negotiate prices with the many exporters in November and December for shipments in the following calendar year. Japanese buyers negotiate their contracts in the January to March period for shipment during the Japanese fiscal year, which begins April 1st.

In price negotiations for deliveries in 1988, the major exporters gained increases of 7.5 to 10% for pellets, but took price cuts of up to 9.6% on fines and concentrates, the fourth price cut in the last five years.

The prices for 1988 deliveries were settled first for most Australian shipments to Japan, then the major European mills and their suppliers in Canada, Australia and Brazil reached agreements. Finally, the negotiations between the Japanese mills and Brazil's largest producer, CVRD, were completed at the end of January.

Happily for the companies concerned, the majority of price negotiations for 1988 deliveries were completed by the end of January, and did not drag into April as had occurred in 1987. The other significant feature was the return to a 16¢ price differential between pellets and concentrate, on the basis of US¢/Fe unit.[1]

Negotiations for 1989 deliveries began in November 1988, and some settlements had been reached in both Europe and Japan before the year-end.

In Japan, Hamersley Iron Pty., Ltd. of Australia settled, in mid-December, for a 13% increase in the price for fines and a 17.3% increase for lump ore. Hamersley also was accorded an increased share of the Japanese market, from 14% to 16%. Australian companies were especially insistent on a price increase since the increase in value of the Australian dollar had lowered the domestic value of the contracts written in U.S. dollars.

Robe River Ltd. and IOC followed Hamersley's lead in settling for a 13% price hike for fines and concentrate sales in Japan. Robe River's share of the Japanese market will increase from 10.5 to 11%. The basic volume for IOC remained at 2.07 Mt for delivery in fiscal 1989-90.

In European negotiations, CVRD of Brazil took the lead by reportedly asking for a 21.3% price hike for fines, but settled for 13% after the Australian-Japanese contracts were signed at that level. Pellet prices, however, were increased by 17.3%, bringing the price differential between fines and pellets to 20.77 ¢/Fe unit.

Overall, prices of iron ore had fallen every year from 1982 to 1988 and the cumulative effect had been a decline of 25% in terms of US¢/Fe unit. For some exporters, the devaluation of their national currencies has meant that the prices for them have not been seriously eroded. During 1987 and 1988, however, the U.S. dollar weakened considerably relative to many currencies and some exporters, especially the Australians, were feeling the effects of the U.S. dollar-denominated price declines of the past five years.

---

[1] Price is reported in cents, United States currency, for each percentage point of iron in a tonne of ore; e.g. at 30¢/Fe unit, ore grading 65% iron would bear a price of 65 x 30¢ = US$19.50/t.

OUTLOOK

Electric furnace mills continued to expand their market share at the expense of integrated mills, and increasing use of continuous casting equipment reduced the amount of pig iron needed for each tonne of product manufactured. Continuous casting reduces the waste of iron units in the processing of crude steel, and thus reduces the consumption of iron ore, in two ways; it increases the yield of product from molten steel and it reduces the amount of home scrap. With less internally generated scrap, the mills purchase more scrap and a higher percentage of the iron units that are used are in the form of purchased scrap instead of iron ore.

Massive restructuring of the international steel industry in recent years, particularly in the United States, had a major impact on the strategies and perspectives of Canadian iron ore producers. Canadian iron ore mines were able to increase the quantities sold to their owners this year due to a number of factors. New price agreements lowered the average price paid by the owners relative to the Lake Erie price which had been the standard for North American shipments. The mines provided 'custom' products for various clients which gave them a quality advantage over offshore competition, and steel demand improved in the United States.

A major factor in improving the competitive position of the U.S. steel industry was a fall in the value of the U.S. dollar relative to many other currencies.

According to United States data, the average value of its imports of Canadian iron ore in the first half of 1988, averaged US$32.66 a short ton although imports from other countries averaged US$18.30 a short ton. As the price for Canadian ore in North America continues the trend toward the world price, the price of Canadian ore will have to fall further even while the world price is rising. At the same time, the Canadian dollar may strengthen relative to the U.S. dollar. The effect of these factors on revenues will continue to be a concern to the mines.

The outlook for steel in Canada and the United States is for maintenance of the strong market, for one more year at least, but a small reduction in annual production, since part of the 1988 production was used to replenish steel stockpiles.

The production of iron ore in Canada is forecasted to remain in the 35 to 40 Mt/y range for the medium term. The proportion of acid pellets, self-fluxed pellets, pellets with specific manganese and silica content, and products not yet available will increase relative to concentrate sales. Self-fluxed pellets will increase market share at the expense of acid pellets.

The market for concentrate and fines, which had been saturated for many years, tightened in 1988 and the major exporters were able to claim significant price increases for deliveries in 1989. The tight market for pellets should also improve the profitability of Canadian mines in the near term.

In order to maintain market share with steel mills in North America and overseas, Canadian iron ore producers continued to cooperate closely with consumers to develop products that are tailored to specific user needs. All exporting companies have plans to continue to improve their product lines.

Employment in the industry is not likely to increase but the restructuring that produced a 50% drop in the past 10 years is now essentially complete and no major layoffs are expected in the near term.

Major exporters of iron ore are finding growing markets in two areas of the Socialist Blocs. The eastern Europe market has been expanding as steel plants look for high grade iron ore to improve the quality of their steel by using blends of Australian, Canadian, Brazilian or Indian iron ore with ore from the U.S.S.R. There are also rumours that some Russian mines are now considered too costly to run and the eastern European steelmakers are being encouraged to find other sources of supply.

The steel program in the People's Republic of China (PRC) will require significant quantities of foreign iron ore in the near term to meet production targets.

In the long term, the Chinese plan to exploit their extensive domestic iron ore reserves, but they recognize that blending of imported ore with their own resources may be the cheapest way to produce consistent runs of high-grade steels. Their joint venture regarding the Channar deposit in Australia would only satisfy part of that potential requirement, and other countries and corporations are approaching the PRC to arrange what may develop into major iron ore trade.

Canadian mines, because of their recent improvements in productivity, should be able to take advantage of some of these market opportunities and maintain their current volume of sales and production.

TABLE 1A. CANADA, IRON ORE PRODUCTION AND TRADE, 1986 AND 1987

	1986[r]		1987	
	(tonnes)[1]	($000)	(tonnes)[1]	($000)
Production (mine shipments)				
Newfoundland	19 184 137	761 328	18 423 302	660 526
Quebec	13 471 247	X	15 987 682	X
Ontario	3 460 954	X	3 229 469	X
British Columbia	50 546	2 217	61 372	2 221
Total[2]	36 166 884	1 342 666	37 701 825	1 395 620
Imports				
Iron ore				
United States	4 637 925	271 127	4 904 645	248 499
Brazil	699 763	22 653	307 852	9 406
Japan	5 000	107	-	-
Italy	62	5	235	18
Switzerland	-	-	13	1
Argentina	24 494	619	-	-
Total	5 367 244	294 511	5 212 745	257 924
Exports				
Iron ore, direct shipping				
United States	564 089	28 783	116 412	2 083
United Kingdom	683 084	21 207	94 839	1 802
Netherlands	54 780	1 753	-	-
Italy	106 750	1 987	47 182	988
West Germany	92 320	2 954	-	-
Total	1 501 023	56 684	258 433	4 873
Iron ore, concentrated				
West Germany	2 188 248	50 492	1 815 941	37 413
United Kingdom	1 424 718	30 262	2 176 222	42 136
France	1 894 401	42 022	1 800 554	33 665
Japan	2 076 192	44 476	1 904 113	38 143
Netherlands	1 884 252	43 555	846 511	19 005
Italy	458 076	10 326	760 509	15 516
United States	634 797	13 050	442 201	9 354
Belgium-Luxembourg	304 612	6 928	327 237	6 914
Philippines	221 059	4 642	614 575	12 306
Austria	238 407	4 940	301 725	5 161
Pakistan	238 472	4 921	173 934	3 406
South Korea	137 992	2 768	136 477	2 379
Portugal	171 616	4 247	116 895	2 464
Spain	57 121	1 347	113 695	2 295
Romania	-	-	257 257	4 711
Yugoslavia	75 347	2 491	-	-
Total	12 005 310	266 467	11 787 846	234 868

TABLE 1A. (cont'd)

	1986[r]		1987	
	(tonnes)[1]	($000)	(tonnes)[1]	($000)
Iron ore, agglomerated				
United States	8 249 746	466 184	8 302 529	413 415
United Kingdom	3 705 455	119 497	4 773 474	153 021
Italy	965 762	45 512	976 887	46 631
West Germany	1 709 292	54 815	1 216 376	40 106
Netherlands	1 425 211	47 561	717 865	25 752
France	360 631	11 201	523 852	16 043
Belgium-Luxembourg	590 486	23 362	238 761	10 053
Portugal	173 460	5 690	233 121	7 107
Japan	-	-	300 787	5 715
Spain	55 006	2 037	185 961	5 830
Austria	102 631	3 334	146 533	4 656
Yugoslavia	151 277	5 202	-	-
Total	17 488 957	784 395	17 616 146	728 329
Iron ore n.e.s., including by-products				
United States	12 950	216	16 893	330
Total	12 950	216	16 893	330
Total exports, all classes				
United States	9 461 582	508 233	8 878 035	425 182
United Kingdom	5 813 257	170 966	7 044 535	196 959
Netherlands	3 364 243	92 869	1 564 376	44 757
West Germany	3 989 860	108 261	3 032 317	77 519
Italy	1 530 588	57 825	1 784 578	63 135
France	2 255 032	53 223	2 324 406	49 708
Belgium-Luxembourg	895 098	30 290	565 998	16 967
Japan	2 076 192	44 476	2 204 900	43 858
Portugal	345 076	9 937	350 016	9 571
Yugoslavia	226 624	7 693	-	-
Austria	341 038	8 274	448 258	9 817
Philippines	221 059	4 642	614 575	12 306
Pakistan	238 472	4 921	173 934	3 406
Spain	112 127	3 384	299 656	8 125
Other countries	137 992	2 768	393 734	7 090
Total	31 008 240	1 107 762	29 679 318	968 400
Consumption of iron ore at Canadian iron and steel plants	14 185 304	..	14 461 502	..

Sources: Energy, Mines and Resources Canada; Statistics Canada; American Iron Ore Association.

[1] Dry tonnes for production (shipments) by province; wet tonnes for imports and exports.

[2] Total iron ore shipments include shipments of by-product iron ore.

[r] Revised; X Confidential; - Nil; n.e.s. Not elsewhere specified; .. Not available.

TABLE 1B. CANADA, IRON ORE PRODUCTION AND TRADE, 1988P

		1988P	
		(tonnes)[1]	($000)
Production (mine shipments)			
	Newfoundland	20 044 216	726 574
	Quebec	15 700 000	X
	Ontario	2 927 065	X
	British Columbia	71 000	3 170
	Total[2]	38 742 281	1 388 129
Imports		(Jan.-Sept.)	
2601.11	Iron ore concentrates, non-agglomerated		
	United States	16 399	436
	Total	16 399	436
2601.12	Iron ore, agglomerated		
	United States	2 947 951	143 154
	Brazil	238 896	7 526
	Total	3 186 847	150 680
Exports			
2601.11	Iron ore concentrates, non-agglomerated		
	West Germany	1 608 023	30 172
	Japan	1 376 276	27 365
	France	1 538 208	26 594
	United States	743 925	20 600
	United Kingdom	1 172 676	20 332
	Netherlands	665 267	13 974
	Italy	384 525	9 575
	South Korea	489 935	8 000
	Belgium	315 440	6 165
	Philippines	179 620	3 412
	Portugal	140 008	2 718
	Spain	108 341	2 395
	Romania	115 058	1 776
	Yugoslavia	113 168	1 656
	Pakistan	66 250	1 186
	Luxembourg	50	433
	East Germany	10	96
	South Africa	75	4
	Total	9 016 855	176 453
2601.12	Iron ore agglomerated		
	United States	7 182 446	334 512
	United Kingdom	3 121 523	104 538
	Italy	591 475	27 286
	Netherlands	632 166	21 621
	France	606 166	19 772
	West Germany	588 813	18 762
	Belgium	252 006	9 336
	Portugal	167 132	5 414
	Austria	198 947	4 862
	Yugoslavia	93 010	4 463
	Spain	60 099	1 878
	Sweden	59 746	1 899
	Total	13 553 529	554 343

TABLE 1B. (cont'd)

	1988P	
	(tonnes)[1]	($000)
Total exports all classes		
United States	7 926 371	355 112
United Kingdom	4 294 199	124 870
West Germany	2 196 836	48 934
France	2 144 374	46 366
Italy	976 000	36 861
Netherlands	1 297 433	35 595
Japan	1 376 276	27 365
Belgium	567 446	15 501
Portugal	307 140	8 132
South Korea	489 935	8 000
Yugoslavia	206 178	6 119
Austria	198 947	4 862
Spain	168 440	4 273
Philippines	179 620	3 412
Sweden	59 746	1 899
Romania	115 058	1 776
Pakistan	66 250	1 186
Luxembourg	50	433
East Germany	10	96
South Africa	75	4
Total	22 570 384	730 796
Consumption of iron ore at Canadian iron and steel plants	14 273 555	..

Sources: Energy, Mines and Resources Canada; Statistics Canada; American Iron Ore Association.

[1] Dry tonnes for production (shipments) by province; wet tonnes for imports and exports.

[2] Total iron ore shipments include shipments of by-product iron ore.

P Preliminary; X Confidential; .. Not available.

TABLE 2. CANADA, IRON ORE PRODUCTION (SHIPMENTS), 1985-88

Company and Location	Ore Mined	Product Shipped	1985	1986	1987	1988P
			(000 tonnes, natural or wet)			
Adams mine, Kirkland Lake, Ont.	Magnetite	Acid Pellets	1 141	-	-	-
		Fluxed Pellets		971	1 036	994
Algoma Ore division of The Algoma Steel Corporation, Limited Wawa, Ont.	Siderite	Sinter	1 382	1 186	1 118	1 050
Griffith mine, Bruce Lake, Ont.	Magnetite	Pellets	789	160	-	-
Iron Ore Company of Canada Schefferville, Que.	Hematite, goethite and limonite	Direct shipping	1 830[1,2]	1 421[1,2]	1 173[1,2]	800[2]
Carol Lake, Lab.	Specular hematite and magnetite	Concentrate	4 997	3 858	2 958	4 100
		Acid Pellets	8 168	9 140	7 920	7 900
		Fluxed Pellets	-	1 152	1 215	2 000
Sept Îles, Que.	Schefferville "treat ore"	Pellets	-	-	-	-
Quebec Cartier Mining Company, Mont Wright, Que.	Specular hematite	Concentrate	8 619	6 947	8 155	8 600
		Acid Pellets	6 638	5 448	7 453	7 480
		Fluxed Pellets		1 384	744	720
Sherman mine, Temagami, Ont.	Magnetite	Acid Pellets	474	-	-	-
		Fluxed Pellets	524	1 036	1 090	895
Wabush Mines, Wabush, Labrador and Pointe Noire, Que.	Specular hematite and magnetite	Pellets	5 696	5 293	5 478	6 100
British Columbia Producers	Magnetite	Pellet Feed, Magnetite Concentrate	87[2]	51[2]	61	71
Other Ontario	Pyrrhotite, magnetite	Pellets, Magnetite Concentrate	140	2	2	2
			40 485	38 049	38 403	49 712

[1] Includes some Carol Lake concentrate. [2] Stockpile ore.
P Preliminary; - Nil.

TABLE 3. RECEIPTS AND CONSUMPTION OF IRON ORE AT CANADIAN IRON AND STEEL PLANTS, AND INVENTORIES, 1987 AND 1988

	1987	Jan.-Nov. 1988
	(000 tonnes)	
Receipts imported	5 196	4 445
Receipts from domestic sources	9 007	8 253
Total receipts at iron and steel plants	14 203	12 698
Consumption of iron ore	14 462	13 085
Inventory at docks, plants, mines and furnace yards, December 31	6 631	6 535
Inventory change	-2 985	-96

Source: American Iron Ore Association.

TABLE 4. WORLD IRON ORE PRODUCTION, 1985-87

	1985	1986	1987e
		(000 tonnes)	
U.S.S.R.	247 640	250 000	251 000
Brazil	128 200	129 540	134 000
Australia	96 430	97 310	104 580
People's Republic of Chinae	131 500	142 480	157 000
India	42 550	48 820	48 420
United States	49 530	39 450	46 990
Canada	39 880	36 170	37 700
Republic of South Africa	24 390	24 480	22 000
France	14 480	11 820	11 240
Liberia	16 120	15 600	13 810
Sweden	20 270	20 480	19 640
Venezuela	14 760	16 720	17 200
Other countries	78 630	80 340	74 560
Total	904 380	913 210	938 140

Source: Association of Iron Ore Exporting Countries (APEF).

e Estimated.

TABLE 5. CANADIAN CONSUMPTION OF IRON-BEARING MATERIALS BY INTEGRATED[1] IRON AND STEEL PRODUCERS, 1987

	Consumed In				
	Sinter	Direct	Iron and Steel Furnaces		
Material Consumed	Sinter Plants at Steel Mill	Direct Reduction Plants	Production of Pig Iron	Steel Furnaces	Total in Furnaces
			(tonnes)		
Iron Ore					
Crude and concentrate	251 917	211 500	16 761	-	16 761
Pellets	105 809	844 400	12 019 691	6 000	12 025 691
Sinter	63 171	-	1 052 659	-	1 052 659
Sinter produced at steel plant	-	-	819 054	-	819 054
Direct reduced iron	-	-	-	678 000	678 000
Other iron-bearing materials including flue dust, mill scale, cinder, slag, etc.	385 985	-	265 562	99 907	365 469
Total	806 882	1 055 900	14 173 727	783 907	14 957 634

Source: Company data.

[1] Dofasco Inc.; Sidbec-Dosco Inc.; Sydney Steel Corporation; The Algoma Steel Corporation, Limited; Stelco Inc.

- Nil.

TABLE 6. NORTH AMERICAN PRICES OF SELECTED ORES AT YEAR-END, 1975, 1980 AND 1985-88

	1975	1980	1985	1986	1987	1988
				(US$)		
Mesabi Non-Bessemer[1]	18.21	28.05	30.03-31.53	30.03-31.53	30.03-31.53	30.03-31.53
Old Range Non-Bessemer and Manganiferous[1]	18.45	28.30	32.78	32.78	32.78	32.78
PELLETS: (per gross ton iron unit)[2]						
Lake Erie Base Price[3]	0.464	0.725	0.869	0.869	0.7245-0.869	0.7245-0.869
USX Corporation[4]	-	-	-	-	0.37344	0.37344
Upper Lakes[5]	-	-	0.594	0.594	0.4684-0.594	0.4684-0.594
Wabush[6]	-	0.635	0.635	0.635	0.635	0.635
Mineral Services Inc.[4]	-	-	0.580	0.580	0.580	0.580
Direct Reduced Iron[7]	-	-	115-135	115-135	115-135	115-135

Sources: Skillings Mining Review; Iron Age.

[1] US$ per gross ton, 51.5% of iron natural, at rail of vessel, lower lake ports. [2] US$ per gross ton natural iron unit. One iron unit equals 1 percentage point of iron content in a ton of ore; an ore containing 60% iron, therefore, has 60 iron units. [3] Cleveland-Cliffs Inc., M.A. Hanna Company, Oglebay Norton Company at rail of vessel lower lake port. [4] At mine. [5] Pickands Mather & Co. and Inland Steel Mining Co. in hold of vessel upper lake port. [6] F.o.b. Pointe Noire. [7] US$ per tonne.

- Nil.

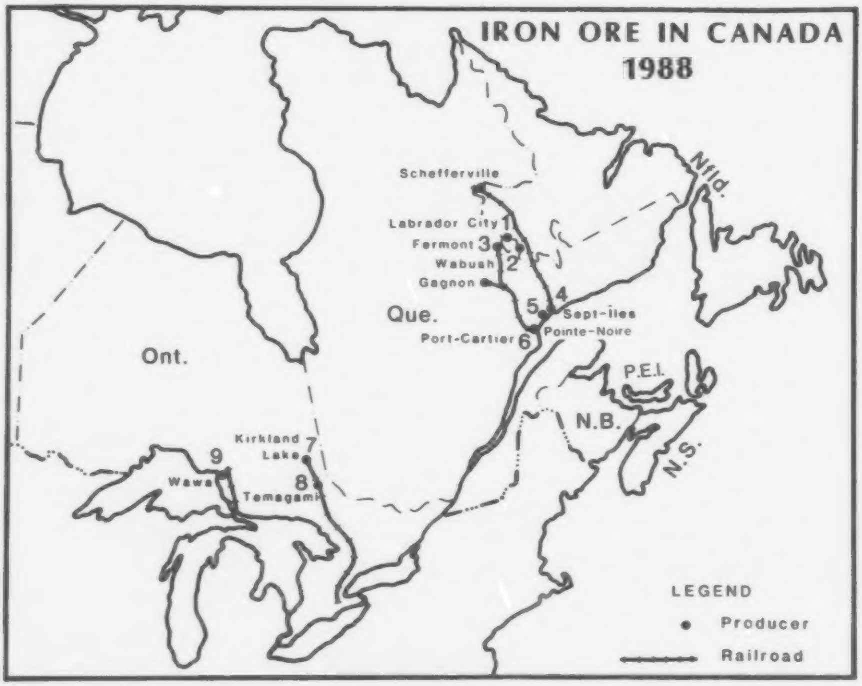
TABLE 7. SELECTED PRICES OF IRON ORE BOUND FOR JAPAN AND EUROPE 1982-88

Ore	Market	Source	1982	1983	1984	1985	1986	1987	1988
			(U.S. cents per Fe Unit Dmt, f.o.b.)						
Fines (including concentrate)	Europe	CVRD	32.5	29.0	26.15	26.56	26.26	24.50	23.50
		Iscor	31.4	27.9	20.6	23.5	22.7	-	-
		Kiruna	34.7	30.1	27.7	28.5	27.9	25.93	26.00
		Carol Lake	33.0	29.3	26.8	26.8	26.5	24.03	23.685
		Mt. Wright	33.0	29.3	26.8	26.8	26.5	24.03	23.685
	Japan	CVRD	30.5	27.5	24.27	24.65	23.66	22.24	20.89
		Iscor	30.5	27.0	23.89	22.26	20.55	19.15	18.03
		Hamersley	34.2	30.5	26.67	27.05	25.97	24.67	23.68
		Carol Lake	29.8	26.7	23.37	23.37	22.44	21.25	19.93
Lump	Europe	Iscor	35.9	31.3	24.0	29.0	26.7	-	-
		Hamersley[1]	44.75	38.15	36.15	38.48	36.2	33.15	36.00[2]
	Japan	CVRD	30.5	27.9	24.27	24.65	23.66	22.24	22.24
		Iscor	35.0	30.6	27.19	25.86	23.91	22.34	-
		Hamersley	40.0	34.9	30.87	31.55	30.29	28.78	28.33
Pellets	Europe	CVRD	47.5	39.0	36.0	36.0	35.6	36.7	40.35
		Kiruna	50.2	41.0	38.6	38.6	38.15	41.15	46.35
		Carol Lake & Pt. Cartier	-	-	-	36.5	36.5	37 15	39.95
	Japan	CVRD (Nibrasco)	53.6	42.9	37.31	36.25	35.29	35.6	-
		Savage River	53.4	-	38.3	37.1	36.02	34.72	34.72

Sources: The Tex Report, Metal Bulletin and Japan Commerce Daily.

[1] C.i.f. Rotterdam. [2] F.o.b. Dampier.

- Not available; Dmt Dry metric tonne; f.o.b. Free on board.


IRON ORE IN CANADA
1988
Schefferville
Labrador City 1
Fermont 3
Wabush 2
Gagnon
Que.
4
5
Sept-Iles
Pointe-Noire
Port-Cartier 6
Nfld.
P.E.I.
N.B.
N.S.
Ont.
Kirkland Lake 7
9
Wawa
8
Temagami
LEGEND
● Producer
Railroad

PRODUCERS
(numbers refer to numbers on map above)

1. Iron Ore Company of Canada,
   Carol Division
   (mine/concentrator/pellet plant)

2. Wabush Mines
   (mine/concentrator)

3. Quebec Cartier Mining Company
   (mine/concentrator)

4. Iron Ore Company of Canada (port)

5. Wabush Mines
   (pellet plant/port)

6. Quebec Cartier Mining Company
   (pellet plant/port)

7. Dofasco Inc.,
   Adams mine
   (mine/concentrator/pellet plant)

8. Dofasco Inc.,
   Sherman mine
   (mine/concentrator/pellet plant)

9. Algoma Ore division of The Algoma Steel
   Corporation, Limited
   (mine/concentrator/sinter plant)

Lead

D. LAW-WEST

In 1988, Canadian mine production of lead decreased by 9% to 333 707 t from 373 215 t in 1987. The production of refined lead from all sources totalled 269 324 t, up from 230 661 t produced in 1987. Canadian consumption of lead was down slightly to an estimated 100 000 t.

The international lead market remained in close balance during the year. Mine production of lead in non-Socialist countries was only marginally higher at 2 375 000 t than the previous year's 2 372 000 t. Refined lead output was 4 248 000 t compared to 4 236 000 t in 1987, while consumption increased to 4 295 000 t from 4 236 000 t. Commercial stocks of lead dropped from 411 000 t at the start of the year to 396 000 t at the end of the year.

As with other base metals, lead prices increased in 1988, albeit not as spectacularly as some. On the London Metal Exchange (LME) prices increased from an average of US27¢/lb. in 1987 to nearly 30¢ in 1988. The average U.S. domestic price increased by only one cent to 37¢/lb. but the year end price was around 42¢.

SUPPLY: CANADIAN DEVELOPMENTS

Detailed information concerning Canada's major base metal mining and milling operations may be found in the table following the commodity reviews.

The drop in Canadian lead concentrate production is in part explained by the closure of the Pine Point mine in the Northwest Territories. While mining operations ceased in 1987, milling continued until the end of the first quarter of 1988. Significant stocks of concentrate remain available at Pine Point for shipping in the future.

Cominco Ltd. continued with the $171 million modernization program at its Trail lead smelter. Production from the first phase is expected to begin by mid-1989.

In November East-West Minerals NL officially opened the Caribou underground mine near Bathurst, New Brunswick. The mine will reach full capacity of 14 000 t/y of lead during 1989.

Hudson Bay Mining and Smelting Co., Limited (HBMS) continued with an expansion program at the Chisel Lake mine in Manitoba. When complete the expanded operation will produce some 5 000 t/y of lead.

Brunswick Mining and Smelting Corporation Limited is increasing its secondary lead production capacity with the addition of two short rotary furnaces at the Belledune plant.

Noranda Minerals Inc. closed the Mattabi mine near Ignace in northern Ontario because ore reserves were exhausted. The closure will reduce Ontario lead production by 2 000 t/y.

Canamax Resources Inc. has reported increased reserves at its wholly-owned Mt. Hundere property north of Watson Lake in the Yukon. Drill indicated reserves are 5.2 Mt grading 12.3% zinc, 5.3% lead and 64 g/t silver. Preliminary metallurgical tests indicate that high grade lead and zinc concentrates can be produced with recoveries in the 90% range. In addition at least 85% of the silver will be recovered with the lead concentrate. The company intends to further delineate the ore deposit in an underground exploration program.

SUPPLY: WORLD DEVELOPMENTS

Western world mine production of lead increased only a few thousand tonnes to 2 375 000 t in 1988 from 2 372 000 t produced in 1987. This indicates an ongoing balance between mine closures and openings.

Australia, the largest lead mine producer, will maintain its position for at least the next few years as large additions totalling an estimated 80 000 t come on-stream in the next few years. The expansion program at the Helleyer lead/zinc/silver mine in Tasmania represents the largest single

---

D. Law-West is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 992-4327.

addition to lead production. When complete in 1990, the operation will produce 38 000 t/y compared to the 12 000 t/y currently produced. The next largest addition will be at the Hilton project owned by M.I.M. Holdings Limited near Mount Isa, Queensland. The silver/lead/zinc mine will produce some 20 000 t/y of lead beginning in 1990.

BHP Minerals Ltd. and Billiton (UK) Ltd. began production at the Cadjebut mine near West Kimberley, Western Australia. The new operation will reach full capacity of 7 500 t/y of lead in 1989. In Queensland, Pancontinental Mining of Australia Ltd. and Outokumpu Oy are planning to bring the Thalanga and the Lady Loretta mines into production with a combined output of 15 000 t/y.

Lead production from Peru was adversely affected by two general mining strikes. Reports suggest that 1988 lead output in Peru, which usually accounts for some 8.1% of western world lead production, declined by 22% to 160 000 t from the 204 000 t produced in 1987.

The United States reported a large increase in lead production, from 318 000 t in 1987 to 400 000 t in 1988. In 1991 an additional 70 000 t/y of lead will be produced when the Red Dog lead/zinc/silver mine in Alaska reaches full production. The new mine/mill complex is being brought into production by Cominco Alaska Incorporated. Half of the lead concentrate will be shipped to the Trail lead smelter.

RECYCLING

Secondary suppl, plays an important role in the world lead markets. Over the past few years it has accounted for about half of the refined metal produced. In 1988 production of refined lead from scrap material was 2 030 000 t or 48% of the total refined lead produced during the year. Secondary lead production is expected to play an increasingly important role in the supply of lead metal in world markets as more emphasis is placed on environmental protection through recycling.

Tonolli Canada Ltd. announced plans to increase the capacity of its secondary lead smelter near Toronto from 30 000 t/y to 40 000 t/y by using an electrowinning technology patented by Engitec Impianti in Italy. The new process requires that the sulphur found in the paste portion of scrap batteries be first removed and captured in a desulphurization process before the batteries are smelted. The sulphur will be sold as sodium sulphate for detergents. The new plant will cost US$3 million.

In the United States RSR Corporation, one of the largest secondary lead producers in the world, announced plans to convert all of its operations to its patented electrowinning process over the next six years. The company plans also to expand each of its operations by about 35 000 t/y. The electrowinning process is more environmentally sound and cost effective than the current smelting process being used.

CONSUMPTION AND USES

Preliminary estimates indicate that lead consumption hit a record 4.295 Mt in 1988 compared with the 4.236 Mt in 1987. Table 5 shows lead consumption by end use in the major consuming countries.

Lead is a bluish-grey metal that is quite dense and malleable. It has a low melting temperature and a high resistance to corrosion. These properties have allowed a broad range of uses to be developed for lead.

The lead acid storage battery used by the transportation industry remains the largest consumer of lead, averaging about 65% of total consumption. In the United States batteries accounted for nearly 78% of all the lead consumed compared with 30% in the United Kingdom. The average automobile battery contains about 10 kg of lead.

The chemical industry is also an important consumer of lead, mainly in the production of tetraethyl lead which is used as an additive to gasoline. This use however will play an ever decreasing role as this form of fuel additive is phased out in most of the industrialized countries in compliance with environmental regulations. Lead oxides and other compounds are used in paints, pigments, glazes and a wide variety of chemicals.

Lead is alloyed with tin in the production of solder used in both the electronics and plumbing industries. Small amounts of lead are sometimes alloyed in steel to make a free-machining steel which is used when a high finish is required after machining.

There are many industrial applications of both pure lead metal and lead alloys, some of which include: power and communication cable sheathing, especially in underground or underwater cables including transoceanic cable systems; pipes and other extruded products; and sound barrier sheeting in office buildings, schools and partitions between multiple housing units.

Lead's high resistance to gamma radiation and X-rays makes it the preferred metal for shielding around X-ray equipment and at nuclear installations. Specialized lead containers for storing nuclear waste material are being evaluated and if acceptable could lead to a large increase in the demand for lead. One container design requires about 5.25 t of lead for each tonne of nuclear waste material which is currently being generated at about 15 300 t/y and rising.

The experimental Chino battery energy storage plant in California could lead to an added demand for some 800 000 t of lead worldwide by the end of the century. The facility became operational in mid-1988 and is designed to supplement existing generators during the peak morning and evening hours without drawing on other sources or building new power plants. The plant required 2 000 t of lead and has the capacity to provide a 10 MW load for four hours and to be regenerated in six to ten hours during off-peak periods. The unit has a design life of 2 000 cycles or eight years. Similar operations are in the design, installation or operation stage in Japan, West Germany, Australia and South Africa, indicating to some extent the acceptance of these types of plants.

MARKETS, PRICES AND STOCKS

The international supply of lead in concentrate form from mine production is widespread around the world (Table 7). The supply of refined lead is somewhat more concentrated (Table 8), situated mainly in Europe, North America and to a lesser extent in Japan and Australia. The consumption of lead is centered on the European, Japanese and American markets. Two prices for lead are commonly quoted, namely the London Metal Exchange (LME) in Europe and the U.S. domestic price in the United States.

Lead prices in 1988 averaged 29.7¢/lb. on the LME and 37¢ in the United States. The accompanying graph plots the daily price of lead during 1988 and Table 3 gives a price history for both quoted prices.

Lead stocks totalled 396 800 t at the end of 1988 compared with the 412 000 t at the beginning of the year. Individual holdings were: producers (150 000 t); consumers (180 000 t); merchants (4 000 t); and the LME (62 000 t). In addition the United States government holds some 545 300 t in its strategic stockpile.

INTERNATIONAL LEAD ZINC STUDY GROUP

The International Lead and Zinc Study Group was formed in 1959 to provide opportunities for regular intergovernmental consultations on international trade in lead and zinc. Particular attention is given to providing continuous information on the supply and demand position and its probable development.

The Group is headquartered in London, England and membership now includes nearly every major lead and zinc producing and consuming country. While it has an extensive information gathering and dissemination role, the Group has no market intervention powers. There is a general meeting held each fall when member countries and their industry advisors meet for discussions. China joined the Group in 1987 as its first foray into independent international commodity organizations.

HEALTH, SAFETY AND THE ENVIRONMENT

Lead has been added to gasoline for automobiles since the mid-1920s. Tetraethyl lead performs as an octane enhancer which allows engines to run with a higher compression ratio, thus increasing engine efficiency. The use of lead in gasoline has led to its widespread distribution at higher concentrations throughout the environment and has resulted in a greater exposure for humans.

The concern about the health impacts of higher lead concentrations in the environment initiated a progressive phase down in the use of leaded gasoline in North America beginning in 1974. There is a similar reduction in the use of lead in gasoline under way in Europe. In 1986 the federal government of Canada decided to eliminate lead from gasoline by the end of 1992. This decision was based on the recognition that lead in automobile emissions posed a real and significant health risk to humans.

The six year phase-out was to allow the petroleum refining industry to increase its lead-free gasoline refining capacity, and enable expansion of facilities to produce lead-free octane enhancers. In September 1988, additional health research indicated that much lower levels of lead in humans could severely affect the human health, especially that of children, than was previously reported. In response, the Canadian government announced that the phase-out date for leaded gasoline would be advanced to December 1, 1990.

The toxicity of lead has long been known but, in the United States, there is a proposal to classify lead and all of its compounds as probable human carcinogens. The International Association for Research on Cancer (IARC) classifies lead as a possible carcinogen. These decisions are based on studies on lead as a carcinogen from nearly twenty years ago and the evidence from these studies does not appear strong enough to support the conclusion that lead and all of its compounds are indeed carcinogenic in humans.

Several interested groups including the Mining Association of Canada (MAC), the International Lead-Zinc Research Organization (ILZRO), the Lead Industries Association (LIA) and Eurometaux are attempting to launch an internationally funded scientific study on lead carcinogenicity similar to a recent study carried out on nickel.

Legislators in Suffolk County, New York, adopted a battery recycling law October 1988. The new law, which is scheduled to take effect in 1990, will add at least $5.00 to the sale price of batteries and to be redeemed when the battery is returned to be recycled. A similar law was adopted in Rhode Island in July 1988. The law is expected to reduce the amount of lead finding its way into the environment from land fill sites.

OUTLOOK

Lead prices on the LME are expected to remain around US30¢/lb. in the short term, but there are indications of some downward pressure on prices as new production is brought on-stream. Much of this new production is in conjunction with new zinc capacity being developed.

In the medium to longer term, mine production of lead is forecast to increase annually until the mid-1990s. However, there will be a geographic redistribution as European production declines and the United States and Australian production increases.

Lead consumption is expected to grow fairly steadily but, as with production, there will be some geographical variance in total amounts. The developing countries are expected to show the greatest growth as demand increases for batteries from the transportation sector.

There is some potential that stationary batteries used as load-levelling power sources by utility companies may increase the demand for lead if trial projects prove economic. However full scale plants are still in the future.

Lead prices are expected to weaken in the longer term and may fall to around 25¢ in constant dollar terms.

TARIFFS

Item No.	Description	Canada MFN	Canada GPT	Canada USA	United States Canada[1]	EEC MFN	Japan[1] MFN
2607.00.00	Lead ores and concentrates	Free	Free	Free	1.5¢/kg on Pb	Free	Free
78.01	Unwrought lead						
7801.10	- Refined lead						
7801.10.10	--- Pig and block	Free	Free	Free	2.7% on Pb	3.5%	8 yen/kg
7801.10.90	--- Other	10.2%	Free	9.1%	2.7% on Pb	3.5%	8 yen/kg
	- Other						
7801.91	-- Containing by weight antimony as the principal other element						
7801.91.10	--- Lead antimony - tin alloys	6.8%	Free	6.1%	2.7% on Pb	3.5%	6.5%
7801.91.90	--- Other	10.2%	Free	9.1%	2.7% on Pb	3.5%	6.5%
7801.99.00	-- Other	10.2%	Free	9.1%	3.1% on Pb	Free	4.7%
7802.00.00	Lead waste and scrap	Free	Free	Free	Free	Free	3.2%
7804.20	- Powders and flakes						
7804.20.10	--- Powders, not alloyed	4%	Free	3.6	3.0%	2.2%	6.5%
7804.20.20	--- Alloyed powders; flakes	10.2%	Free	9.1	3.0%	2.2%	6.5%

Sources: Customs Tariffs, effective January 1989, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States (First Edition Supplement 2) effective January 1, 1989; Official Journal of the European Communities, Vol. 30, No. L256, 1987, "Conventional" column; Custom Tariff Schedules of Japan, 1988.

[1] GATT rate is shown, lower tariff rates may apply circumstantially.

TABLE 1A. CANADA, LEAD PRODUCTION, TRADE AND CONSUMPTION 1985-87

	1985		1986		1987	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Production						
All forms[1]						
Nova Scotia	-	-	-	-	x	x
New Brunswick	68 375	39 462	66 590	45 341	66 485	70 333
Ontario	3 812	2 200	6 287	4 281	6 092	6 444
Manitoba	740	427	590	402	x	x
British Columbia	116 811	67 418	91 947	62 607	57 078	60 382
Yukon	1 470	848	35 091	23 893	x	x
Northwest Territories	77 083	44 488	133 836	91 129	131 744	139 370
Total	268 291	154 843	334 342	227 654	373 215	394 817
Mine output[2]	284 595	..	349 281	..	423 207	..
Refined production[3]	173 220	..	169 934	..	230 661	..
Exports						
Lead contained in ores and concentrates						
Japan	40 334	10 475	58 026r	16 862r	64 165	27 149
Belgium-Luxembourg	11 534	2 044	16 400	3 418	52 259	21 629
Italy	5 356	1 036	11 452	2 878	23 650	9 099
West Germany	19 987	3 295	9 002r	2 161r	20 445	7 987
United States	11 155	3 899	6 057r	1 963r	8 606	3 975
United Kingdom	3 310	654	4 039	845	3 607	1 131
France	1 981	400	2 122	459	2 202	746
Spain	-	-	2 364	683	-	-
Other	-	-	8 911	1 939	33 002	10 670
Total	93 657	21 802	118 373r	31 208r	207 936	82 386
Lead and alloy scrap, dross, etc. (gross weight)						
Brazil	3 439	1 070	10 497	2 287	11 080	3 590
United States	2 116	1 010	2 987	895	4 262	2 235
Taiwan	168	29	4 284	648	2 933	646
United Kingdom	767	436	915	555	890	356
West Germany	505	135	3 743	965	1 052	229
Korea, Republic of (South)	447	76	0	0	777	139
Spain	204	45	-	-	-	-
Belgium-Luxembourg	892	302	-	-	-	-
Netherlands	2 385	694	1 018	526	-	-
Other	299r	43r	2 012	456	172	46
Total	11 222	3 840	25 456	6 331	21 966	7 242

Lead pigs, blocks and shot						
United States	73 954	37 811	82 524	49 136	62 994	55 448
United Kingdom	28 300	12 851	20 980	10 009	19 422	13 199
Italy	302	193	3 268	1 951	5 958	5 468
Belgium-Luxembourg	4 994	2 826	1 237	676	4 924	4 495
West Germany	1 095	483	1 002	641	4 009	3 969
People's Republic of China	-	-	1 000	448	499	398
U.S.S.R.	773	431	-	-	-	-
Other	4 575	2 470	1 820^{r}	867	2 398	1 586
Total	113 993	57 064	111 831	63 729	100 204	84 564
Lead fabricated materials n.e.s.						
United States	14 516	9 021	18 241	12 054	16 238	15 949
Brazil	-	-	1 376	287	4 106	1 795
Japan	1 110	1 008	1 351	1 295	1 117	1 256
Other	396^{r}	276^{r}	1 995^{r}	1 321^{r}	2 119	1 543
Total	16 022	10 305	22 963	14 957	23 580	20 543
Imports						
Lead pigs, blocks and shot						
United States	3 012	1 970	3 253	2 167	6 034	5 733
Mexico	2 660	1 460	455	257	4 317	4 090
Other	3	3	539	327	2 207	2 117
Total	5 675	3 433	4 247	2 751	12 558	11 940
Lead oxide, dioxide and tetroxide (gross weight)						
United States	1 757	1 631	1 768	1 850	5 157	6 379
Other	312	289	383	373	366	462
Total	2 069	1 920	2 151	2 223	5 523	6 840
Lead fabricated materials n.e.s.						
United States	482	840	868	1 279	1 747	3 226
Other	31	53	64	110	120	284
Total	513	893	932	1 389	1 867	3 511
Lead in crude ores	295	90	38	3	157	76
Lead in dross, skimmings and sludge (gross weight)	-	-	35	7	221	138
Lead and lead alloy scrap (gross weight)						
United States	44 249	5 879	61 238	7 674	73 821	13 513
Other	59	5	292	28	331	77
Total	44 308	5 884	61 530	7 702	74 152	13 590

TABLE 1A. (cont'd)

	1985			1986			1987P		
	Primary	Secondary[5]	Total	Primary	Secondary[5]	Total	Primary	Secondary[5]	Total
Consumption[4]									
Lead used for, or in the production of:									
Antimonial lead	3 452	x	x	4 462	x	x	x	20 874	x
Batteries and battery oxides	34 627	7 767	42 394	26 831	11 240	38 071	28 342	12 085	40 427
Chemical uses; white lead red lead, litharge, tetraethyl lead, etc.	14 395	3 065	17 460	9 635	x	x	12 587	x	x
Copper alloys; brass, bronze, etc.	278	123	401	414	72	486	480	45	525
Lead alloys:									
solders	1 197	6 085	7 282	2 034	2 678	4 712	1 623	2 424	4 047
others (including babbitt, type metals, etc.)	421	2 482	2 903	552	2 740	3 292	x	x	3 392
Semi-finished products: pipe, sheet, traps, bends, blocks for caulking, ammunition, etc.	4 483	x	x	1 290	x	x	920	1 545	2 465
Other lead products	3 134	x	x	5 613	2 875	8 488	6 125	5 834	11 959
Total, all categories	61 987	42 460[r]	104 447[r]	50 849	43 831	94 680	54 500	48 393	102 893

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Lead content of base bullion produced from domestic primary materials (concentrates, slags, residues, etc.) plus estimated recoverable lead in domestic ores and concentrates exported. [2] Lead content of domestic ores and concentrates produced. [3] Primary refined lead from all sources. [4] Available data, as reported by consumers. Confidential data (x) included in "other". [5] Includes all remelt scrap lead used to make antimonial lead.
[r] Revised; - Nil; .. Not available; n.e.s. Not elsewhere specified; x Confidential.
Note: Totals may not add due to rounding.

TABLE 1B. CANADA, LEAD PRODUCTION AND TRADE, 1988P

Item No.		1988P	
		(tonnes)	($000)
Production			
All forms[1]			
New Brunswick		73 289	73 289
Ontario		2 268	2 268
Manitoba		x	x
British Columbia		90 086	90 086
Yukon		x	x
Northwest Territories		67 227	67 227
Total		333 707	333 707
Mine output[2]		368 444	..
Refined production[3]		269 324	..
Exports		(Jan.-Sept.)	
2607.00	Lead ores and concentrates		
	Japan	32 209	13 825
	Belgium	25 876	10 762
	Italy	21 307	10 155
	Australia	13 177	6 868
	Korea, South	10 440	5 325
	Germany, West	10 991	4 191
	United States	4 388	2 345
	Total	118 388	53 471
2608.00	Zinc ores and concentrates		
2608.00.20	Lead content	25 207	11 956
78.01	Unwrought lead		
7801.10	- Refined lead		
	United States	68 626	62 206
	United Kingdom	31 550	24 429
	Belgium	10 704	9 972
	Korea, South	5 808	4 238
	Netherlands	4 385	4 046
	Italy	3 613	3 543
	Other countries	6 754	5 078
	Total	131 440	113 512
	- Other		
7801.91.00	-- Containing by weight antimony as the principal other element	11 363	10 901
7801.99.00	-- Other	8 014	7 853
7802.00	Lead waste and scrap		
	United States	1 980	770
	Korea, South	932	298
	United Kingdom	449	140
	Japan	25	58
	Taiwan	193	54
	Other countries	109	33
	Total	3 687	1 353

TABLE 1B (cont'd)

Item No.		1988P Jan.-Sept.	
		(tonnes)	($000)
7803.00	Lead bars, rods, profiles and wire		
	United States	253	508
	Nicaragua	4	47
	Singapore	11	14
	Barbados	2	3
	Total	270	572
78.04	Lead plates, sheets, strip and foil; lead powders and flakes		
	- Plates, sheets, strip and foil		
7804.11	-- sheets, strip and foil of a thickness (excluding any backing) 0.2mm	18	16
7804.19	-- Other	3 472	1 706
7804.20	- Powders and flakes	114	200
7805.00	Lead tubes, pipes and tube or pipe fittings (for example, couplings, elbows, sleeves)	4	14
7806.00	Other articles of lead		
	United States	..	980
	Brazil	..	402
	Iran	..	81
	Austria	..	16
	Other countries	..	16
	Total	..	1 495
Imports			
2607.00	Lead ores and concentrates		
	Peru	3 499	32 692
	United States	5 841	10 421
	Australia	2 260	1 812
	Italy	2	776
	Bolivia	27	564
	Total	11 629	46 265
2608.00.00	Zinc ores and concentrates		
2608.00.00.20	----- Lead content	601	272
78.01	Unwrought lead		
7801.10	- Refined lead		
7801.10.10.00	--- Pig and block	10 258	9 550
7801.10.90.00	--- Other	262	301
7801.91.00.00	-- Containing by weight antimony as the principal other element	14	29
7801.99.00.00	-- Other	509	493
7802.00	Lead waste and scrap		
	United States	30 317	10 474
	United Arab Emirates	190	84
	Germany, West	20	78
	Cuba	54	42
	Indonesia	86	29
	U.S.S.R.	25	8
	Total	30 692	10 715

TABLE 1B (cont'd)

Item No.		1988P Jan.-Sept.	
		(tonnes)	($000)
7803.00	Lead bars, rods, profiles and wire		
	United States	257	376
	United Kingdom	3	3
	Belgium	5	5
	Other countries	3	4
	Total	268	388
78.04	Lead plates, sheets, strip and foil; lead powders and flakes		
	- Plates, sheets, strip and foil		
7804.11	-- Sheets, strip and foil of a thickness (excluding any backing) < 0.2mm	164	261
7804.19	-- Other	671	628
7804.20	- Powders and flakes	7	12
7805.00	Lead tubes, pipes and tube or pipe fittings (for example, couplings, elbows, sleeves)	53	107
7806.00	Other articles of lead		
	United States	..	2 209
	Japan	..	103
	Germany, West	..	85
	Netherlands	..	26
	United Kingdom	..	14
	Other countries	..	40
	Total	..	2 477

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Lead content of base bullion produced from domestic primary materials (concentrates, slags, residues, etc.) plus estimated recoverable lead in domestic ores and concentrates exported. [2] Lead content of domestic ores and concentrates produced. [3] Primary refined lead from all sources.

P Preliminary; x Confidential; .. Not applicable or not available; - Nil.
Note: Totals may not add due to rounding.

TABLE 2. CANADA, LEAD PRODUCTION, TRADE AND CONSUMPTION, 1970, 1975, 1980, 1982-87

	Production		Exports				
	All forms[1]	Refined[2]	In ores and concentrates	Refined	Total	Imports Refined[3]	Consumption[4]
				(tonnes)			
1970	353 063	185 637	186 219	138 637	324 856	1 995	85 360
1975	349 133	171 516	211 909	110 882	322 791	1 962	89 192
1980	251 627	162 463	147 008	126 539	273 547	2 602	106 836
1982	272 187	174 310	106 744	146 130	252 874	5 661	103 056
1983	271 961	178 043	85 459	147 263	232 722	2 550	88 579
1984	264 301	174 987	114 720	124 149	238 869	6 313	111 642
1985	268 291[r]	173 220	93 657	113 993	207 650	5 675	104 447[r]
1986	334 342	169 934	118 373[r]	111 831	230 204[r]	4 247	94 680[r]
1987	373 215	230 661	207 936	100 204	308 140	12 558	102 893[P]

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Lead content of base bullion produced from domestic primary materials (concentrates, slags, residues, etc.) plus the estimated recoverable lead in domestic ores and concentrates exported.
[2] Primary refined lead from all sources. [3] Lead in pigs and blocks. [4] Consumption of lead, primary and secondary in origin as measured by survey of consumers.
[P] Preliminary; [r] Revised.

TABLE 3. AVERAGE ANNUAL LEAD PRICES 1975-88

Year	London Metal Exchange				U.S. Domestic
	Settlement		3 Months		
	(£/t)	(US¢/lb.)	(£/t)	(US¢/lb.)	(US¢/lb.)
1975	185.63	18.755	186.78	18.821	21.529
1976	250.70	20.480	259.79	21.275	23.102
1977	354.11	28.022	359.12	28.433	30.703
1978	342.79	29.886	342.94	29.895	33.653
1979	567.66	54.574	542.66	52.161	52.642
1980	391.29	41.237	392.08	41.343	42.455
1981	363.37	33.327	370.93	34.025	36.531
1982	310.72	24.679	321.55	25.516	25.547
1983	279.97	19.290	290.62	19.983	21.377
1984	332.49	20.156	333.20	20.196	25.548
1985	304.01	17.876	304.03	17.877	19.067
1986	277.36	18.456	277.61	18.473	22.047
1987	363.66	27.098	346.40	25.736	35.943
1988	368.40	29.748	358.35	28.834	37.140

Sources: London Metal Exchange; Metals Week.

TABLE 4. AVERAGE MONTHLY LEAD PRICES 1987 AND 1988

	London Metal Exchange				U.S. Domestic	
	Settlement		3 Months			
	(£/t)	(US¢/lb.)	(£/t)	(US¢/lb.)	(C¢/lb.)	(US¢/lb.)
1987						
January	308.29	21.052	299.42	20.466	37.9	27.9
February	301.29	20.882	301.15	20.873	34.7	26.0
March	305.85	22.090	298.89	21.587	34.3	26.0
April	340.56	25.186	317.92	23.511	36.7	27.8
May	416.00	31.448	368.26	27.839	46.9	35.0
June	386.36	28.545	363.52	26.857	49.4	36.9
July	412.43	30.100	389.85	28.452	55.2	41.7
August	412.18	29.876	389.61	28.240	55.6	42.0
September	393.27	29.367	377.55	28.194	55.2	42.0
October	361.86	27.279	354.90	26.754	55.0	42.0
November	361.74	29.012	343.79	27.573	55.3	42.0
December	360.40	29.723	345.74	28.514	54.9	42.0
1988						
January	370.20	30.247	349.84	28.583	51.5	40.1
February	372.95	29.743	346.29	27.617	45.8	36.1
March	353.89	29.267	335.15	27.717	44.3	35.5
April	345.74	29.455	331.63	28.253	43.9	35.5
May	357.50	30.314	336.41	28.523	43.8	35.4
June	381.30	30.731	364.51	29.377	43.2	35.6
July	363.17	28.089	363.32	28.100	43.5	36.0
August	354.48	27.285	358.02	27.558	44.0	36.0
September	362.11	27.659	367.05	28.037	45.8	37.3
October	376.81	29.673	377.29	29.711	47.4	39.3
November	382.27	31.359	378.76	30.071	49.7	40.8
December	400.35	33.156	391.95	32.461	49.3	41.2

Sources: London Metal Exchange; Metals Week.

TABLE 5. NON-SOCIALIST WORLD LEAD CONSUMPTION 1984-87

	1984		1985		1986		1987[1]	
	(000 t)	(%)	(000 t)	(%)	(000 t)	(%)	(000 t)	(%)
Batteries	2 066.6	56.7	2 120.4	58.0	2 146.1	59.4	1 711.0	62.6
Cable sheathing	211.4	5.8	211.6	5.8	202.0	5.6	68.0	2.5
Rolled and extruded products	299.3	8.2	277.6	7.6	284.3	7.9	211.0	7.7
Shot/ammunition	104.7	2.9	101.8	2.8	92.0	2.5	52.0	1.9
Alloys	166.2	4.6	154.1	4.2	140.2	3.9	113.0	4.1
Pigments and other compounds	485.2	13.3	509.1	13.9	494.4	13.7	366.0	13.4
Gasoline additives	165.7	4.5	134.3	3.7	110.4	3.0	92.0	3.4
Miscellaneous	144.9	4.0	148.0	4.0	143.4	4.0	120.0	4.4
Total	3 644.0	100.0	3 656.9	100.0	3 612.8	100.0	2 733.0	100.0

Source: International Lead and Zinc Study Group.

[1] 1987 statistics are for: Australia, Canada, France, Germany, F.R., Japan, Mexico, United Kingdom and United States.

TABLE 6. REFINED LEAD CONSUMPTION BY COUNTRY 1984-88

	1984	1985	1986	1987	1988
			(000 t)		
Canada	122	104	95	103	96
United States	1 134	1 124	1 134	1 203	1 190
Mexico	110	125	103	100	76
Brazil	64	73	92	93	90
Other America	83	84	93	95	99
Total America	1 513	1 510	1 517	1 594	1 551
United Kingdom	295	274	282	288	295
Germany, F.R.	357	346	359	345	376
Italy	238	235	238	244	255
France	209	208	205	207	217
Spain	107	116	112	128	127
Other EEC	191	183	196	187	191
Other Europe	225	252	270	253	257
Total Europe	1 622	1 614	1 662	1 652	1 718
Japan	391	397	389	378	403
Korea, Rep.	57	81	88	122	140
China	41	40	59	75	80
India	60	72	77	70	72
Other Asia	133	145	154	166	177
Total Asia	682	735	767	811	872
Australia	59	59	60	62	62
Other Oceania	12	10	8	8	9
Total Oceania	71	69	68	70	71
South Africa	42	48	49	51	54
Egypt	11	14	13	17	19
Algeria	11	14	13	15	12
Other Africa	20	22	21	26	26
Total Africa	84	98	96	109	111
Total Non-Socialist World	3 972	4 026	4 110	4 236	4 323

Source: International Lead and Zinc Institute.

TABLE 7. LEAD MINE PRODUCTION BY COUNTRY 1984-88

	1984	1985	1986	1987	1988
			(000 t)		
Canada	307	285	249	414	367
United States	335	424	353	318	393
Mexico	193	187	197	177	180
Peru	196	210	194	204	153
Other America	80	77	63	50	61
Total America	1 111	1 183	1 056	1 163	1 154
Yugoslavia	114	115	103	94	95
Sweden	80	76	89	89	87
Spain	96	87	82	82	74
Ireland	37	35	36	34	33
Germany, F.R.	27	26	22	25	18
Other EEC	67	61	52	56	69
Other Europe	11	11	10	10	8
Total Europe	432	411	394	390	384
Japan	49	50	40	28	23
Iran	20	21	20	20	18
Thailand	24	29	38	34	30
India	19	26	25	29	27
Other Asia	30	29	40	29	32
Total Asia	142	155	163	140	130
Australia	418	474	418	455	459
South Africa	137	123	125	123	136
Morocco	101	107	73	72	65
Zambia	24	23	24	23	21
Other Africa	9	7	7	6	6
Total Africa	271	260	229	224	228
Total Non-Socialist World	2 374	2 483	2 260	2 372	2 355

Source: International Lead and Zinc Institute.

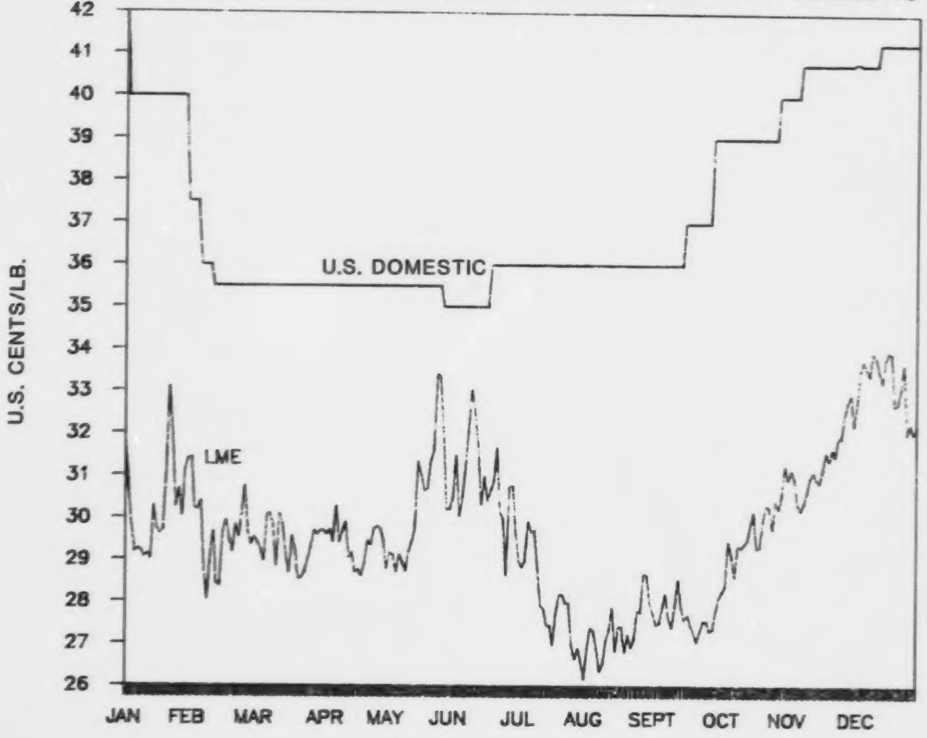
TABLE 8. REFINED LEAD PRODUCTION BY COUNTRY 1984-88

	1984	1985	1986	1987	1988
			(000 t)		
Canada	254	240	258	226	268
United States	965	1 054	932	1 028	1 041
Mexico	172	203	185	185	179
Brazil	64	73	85	88	73
Peru	72	83	66	71	52
Other America	52	55	56	56	59
Total America	1 579	1 708	1 582	1 654	1 672
United Kingdom	338	327	329	347	357
Germany, F.R.	357	356	367	341	350
Italy	146	140	132	168	158
France	206	224	231	246	256
Spain	160	168	130	126	118
Yugoslavia	100	123	138	128	127
Other EEC	191	173	161	149	181
Other Europe	105	102	107	116	112
Total Europe	1 603	1 613	1 595	1 621	1 659
Japan	363	367	362	339	344
Korea, Rep.	27	36	60	83	91
China	44	49	54	66	68
India	24	24	29	33	31
Other Asia	53	63	60	64	72
Total Asia	511	539	565	585	606
Australia	220	216	171	215	177
Other Oceania	6	4	4	4	5
Total Oceania	226	220	175	219	182
South Africa	67	75	70	75	69
Morocco	48	63	55	62	65
Zambia	9	10	7	9	6
Other Africa	16	11	13	11	10
Total Africa	140	159	145	157	150
Total Non-Socialist World	4 059	4 239	4 062	4 236	4 269

Source: International Lead and Zinc Institute.

DAILY LEAD PRICES 1988

LONDON METAL EXCHANGE AND UNITED STATES DOMESTIC



Lime

M. PRUD'HOMME

CANADIAN DEVELOPMENTS

Lime is a high-bulk, comparatively low-cost commodity which is usually sold within a 300 km radius of production centres due to the important contribution of freight charges over consumer's costs. The preferred location for a lime plant is obviously near the principal lime markets, adjacent to a source of high-quality raw material and close to a supply of energy. The more heavily populated and industrialized provinces of Ontario and Quebec together produce over 80% of Canada's total lime output, with Ontario contributing about two-thirds of Canada's total. Production figures do not include some captive production from pulp and paper plants that burn sludge to recover lime for re-use in the causticization process.

In 1988, thirteen producers operated eighteen plants in six provinces. Shipments amounted to 2.54 Mt, an 8.8% increase over 1987, and were mainly from Ontario (65%) and Quebec. The unit value of shipment rose 4% to $74.92/t. Canada's lime calcining capacity was estimated at 3.55 Mt/y and producers operated at 71% of capacity in 1988. Employment remained stable at 850 workers.

The lime industry continued to be characterized by its duality in the distribution of lime products; close to 26% of production is for captive usage in sugar refining plants, steel and chemical plants. These figures do not include recycled slaked lime from pulp and paper mills.

Most of the hydrated lime was sold in the merchant market for use in waste water treatment, soil neutralization, road stabilization and mining. Demand for quicklime improved in 1988 due to the strong performance of the pulp and paper and the steel sectors. Demand for waste water treatment, flue gas scrubbing and mining remained firm. The merchant market is mostly supplied by Ontario (50% of its production), New Brunswick, Quebec and western Canada, whereas some tonnage is used captively by sugar refining plants.

In New Brunswick, the Havelock Lime division of Dickenson Mines Limited commissioned a new vertical shaft kiln at Havelock. The expansion increased the plant calcining capacity by 50% to 100 000 t/y while allowing significant reductions in fuel costs. A further expansion is planned for the production of hydrated lime during 1989.

In Quebec, Shawinigan Carbide Inc. shelved the planned reactivation of its idle 195 000 t/y carbide lime plant near Shawinigan. Meanwhile, several firms have expressed interest in the production of lime and dolime in various locations in Quebec, namely near Quebec City, in the Eastern Townships, western and northwestern Quebec.

In Ontario, Pfizer Inc. announced the construction of a precipitated calcium carbonate (PCC) plant at Dryden. Construction commenced late in 1988 and is scheduled for completion by mid-1989. Lime and carbon dioxide will be used as feedstocks. The 30 000 t/y plant will mostly be dedicated to a nearby pulp and paper mill for use as a filler in a new alkaline papermaking process.

Dofasco Inc., of Hamilton, which owns lime producing facilities at Ingersoll and Guelph acquired the assets of The Algoma Steel Corporation, Limited, a steel producer with a captive lime operation based near Sault Ste. Marie.

In western Canada, Steel Brothers Canada Ltd. sold its construction products division and restructured its other divisions, including the lime units under a new corporation: Continental Lime Ltd.; the company completed the construction of a

---

M. Prud'homme is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 992-3258.

42 000 t/y plant for precipitated calcium carbonate (PCC) near Prince Albert in Saskatchewan. The $7 million project was commissioned late in 1988 and will use lime from the Exshaw facilities. PCC will be sold to Weyerhaeuser Canada Ltd. for use as a filler at the nearby neutral paper plant.

Texada Lime, a division of BP Resources Canada Limited, brought a new 80 000 t/y hydrated lime unit on-stream at its Fort Langley plant in British Columbia. Lime products will be used mainly for acid gas scrubbing.

Exports of lime continued to decline steadily over the last ten years. In 1987, they amounted to 163 800 t and were shipped mainly to the United States from Quebec, Ontario and British Columbia. During 1987, imports remained stable at 44 300 t, mainly for delivery in Ontario (56%) and Alberta (18%).

On a nine-month basis in 1988, imports dropped 30% to 24 300 t, while the unit value for imports rose drastically to $143.68/t from $89.51/t. Exports fell 23% to 98 425 t of which quicklime accounted for two thirds. The unit value of exports increased 11% to $92.71/t.

The lime industry is energy intensive, thus production costs are closely related to current volatile energy costs. Coal is the leading fuel for lime calcining; use of gas and oil is declining. The importance of efficient fuel conserving equipment has been recognized as new plants have incorporated preheater systems, computerized process control systems and improved kiln technology. The industry, on average, uses about 6.4 gigajoules/t of production while new plants consume less than 4.2 gigajoules/t.

Published prices for lime represent only a range of prices. Actual prices vary according to established marketing strategies and market balance. Average Canadian prices for high calcium quicklime and for high calcium hydrated lime, f.o.b. plant, in bulk, were quoted at $63.60/t and $66.40/t respectively at the end of 1988, a rise of 10% over 1987 when prices were stable. These price trends indicate mature market conditions that have been prevailing since 1984.

USES

Carbonate rocks are basic to industry and, fortunately, are widely distributed and easily exploitable. The principal carbonate rocks utilized by industry are limestones - sedimentary rocks composed mainly of the mineral calcite ($CaCO_3$) - and dolomites - sedimentary rocks composed mainly of the mineral dolomite ($CaCO_3.MgCO_3$). Commonly termed limestones, they can be classified according to their content of calcite and dolomite. Their importance to the construction industry is not only as building stone and aggregate but as the primary material in the manufacture of portland cement and lime. Limestones are also used as flux material, in glass manufacture, in refractories, as fillers, abrasives, soil conditioners and in the manufacture of a host of chemicals.

Quicklime (CaO or CaO.MgO) is formed by the process of calcination, in which limestones are heated to the dissociation temperature of the carbonates (as low as 402°C for $MgCO_3$ and as high as 898°C for $CaCO_3$) and held at that temperature over sufficient time to release carbon dioxide. The term "lime" is often used to refer to a multitude of forms of calcareous material; however, lime is essentially a general term that should refer only to the burned or calcined limestone (burnt lime or quicklime) and its secondary products, slaked lime and hydrated lime (or calcium hydroxide). High calcium quicklime is commercially available in six forms: lump lime, crushed or pebble lime, ground lime, pulverized lime, and briquettes or pelletized lime. Slaked lime is the product of mixing quicklime and water and could be obtained as a putty, dry powder or slurry. Hydrated lime is slaked lime dried and reground, and comes in various purities, such as high calcium, dolomitic, magnesian or hydraulic (containing siliceous, aluminous or ferrous impurities). Aglime or agricultural lime is essentially a reference to pulverized limestone used for soil neutralization in a very seasonal market involving primary fall and spring spreading seasons.

Calcining is done in kilns of various types, but essentially those of vertical or rotary design are used. Of comparatively recent design are the rotary hearth, travelling grate, fluo-solid and inclined vibratory types. The cost of energy has made it imperative to include preheating facilities in any new plant design, and environmental regulations have necessitated the incorporation of dust collection equipment.

Lime is widely used in several diversified sectors; however, markets could be classified in four major groups: metallurgical, industrial, agricultural and construction.

The metallurgical industry provides the largest single market for lime. Lime is consumed by steel furnaces as a basic flux which enables impurities - silica, aluminum, phosphorus, sulphur - to melt and form a slag. The lime consumption in a basic oxygen furnace averaged 64 kg/t of steel, and around 30 kg/t in an electric furnace. With increased application of the basic oxygen furnace in the steel industry, lime consumption increased greatly in certain areas of the United States and Canada. Dolime, a pure dolomitic quicklime is also used to enhance the durability and servicability of refractory lining to furnaces.

The industrial markets for lime comprise mainly the pulp and paper industry, mining operations, chemical manufactures, and environmental control works. The pulp and paper industry remains the second largest consumer of lime, most of which is used in the preparation of digesting liquor for the manufacture of kraft or sulphate paper, and in pulp bleaching. Although most of the lime used is recovered in pulp mill by calcining dewatered calcium carbonate sludges resulting from the causticization reaction, an important volume of lime is required as makeup. However, in the short term, the demand for quicklime could increase due to potential substitution of caustic soda used in the process of recausticizing; the market for caustic soda is facing volatile prices and tight supplies in a period of intense consumption, resulting from high operating rates in the pulp and paper sector.

In the mining sector, lime is used by the uranium industry to control hydrogen-ion concentration in the extraction process, to recover sodium carbonate and to neutralize waste sludges. Lime is also used for cyanidation and neutralization in the recovery of gold and silver by flotation process. The chemical manufactures require lime for the production of sodium carbonate (soda ash) and bicarbonate of soda; lime is also used to produce chloralkali, calcium carbide and calcium cyanimide.

Environmental controls are becoming more and more stringent and require a growing volume of lime to treat liquid wastes and industrial gaseous effluents. The largest environmental use for lime is potable water softening and clarification. Lime is also used in waste water treatment for chemical precipitation, acidity neutralization and industrial sludges stabilization.

The growing concern for the safe-guarding and treatment of water supplies and the appeal for enforced anti-pollution measures should result in greater use of lime for water and sewage treatment. Lime is an effective reagent for neutralizing acids and has a basicity factor of 0.96 for high calcium quicklime compared to 0.70 for caustic soda, and 0.54 for high calcium limestone. Air pollution control is a major developing market; flue gas desulphurization or scrubbing units use lime to remove sulphur dioxide (SO_2) from the burning of high sulphur coal, oil and lignite; the removal is made with quicklime, either during the burning procedure or from stack gases by dry injection, or wet or dry scrubbing. Limestone and magnesium oxide could also substitute lime although the latter has shown better process performance and reliability. This may become a major market for this commodity as SO_2 emission regulations are developed. Lime is effective for this purpose, inexpensive, and can be regenerated in systems where the economics would so dictate. The creation of large amounts of gypsum waste sludge during SO_2 removal will present a disposal problem; however, desulfurization solid wastes could be disposed through ponding, landfill or conversion into useful products for use in roadbases, landfill reclamations and synthetic aggregates.

In agriculture, lime has been used for neutralizing soil acidity, but nowadays, agricultural liming is essentially done with pulverized limestone or aglime. Dolomitic liming is also performed on some sandy soils for balancing magnesium deficiencies.

Uses in the construction sector offer a potential growing market for lime in soil stabilization. Quicklime is used to react with fine-grained cohesive soil, such as plastic clays containing silica and alumina to form a dry, impervious, cemented and stable mass. It improves workability, strength and moisture stability and reduces swell-susceptibility. Clay subgrades may be stabilized for highways, airfields, and parking lots. The use of hydrated lime, both in dry or slurry form, is an effective means to improve the moisture resistance of asphalt mixture, when applied to aggregate in order to prevent stripping.

Miscellaneous uses of lime include sugar refining to help in the purification of crude sugar juices by removing acid compounds; in controlled atmospheric storage to extend freshness of fruits and vegetables; in petroleum refining for the neutralization of sulphur compounds and sulphur dioxide emissions; and in the making of plaster, mortar, leather and rubber, paint, glass, dolomite refractories and calcium silicate bricks.

INTERNATIONAL DEVELOPMENTS

World production of lime in 1987 rose slightly to 111 Mt. The U.S.S.R., the largest producer, accounted for 26% of this total, followed by the United States (13%), Japan (6%) and West Germany (5%). Canada ranked fifteen with a 2% share.

United States. In 1988, 73 lime producers at 116 plants shipped 15.1 Mt, a 6.2% increase over 1987. The merchant market grew slightly, accounting for 85%. The increase in production resulted from recovering demand from the metallurgical and the basic refractories sectors. Lime was mainly consumed in steel furnaces, water treatment, construction, pulp and paper and refractories; however, demand from the agricultural sector dropped. Apparent consumption continued to grow steadily since 1986 to 15.3 Mt in 1988. The average unit value for lime remained flat at US$45.35/t, f.o.b. plant. Imports amounted to 143 000 t, an 11.2% drop from 1987, and were mainly from Canada.

OUTLOOK

Demand for lime in Canada is expected to show a modest growth at an average annual rate of 2% over the next three years. Markets in steel, pulp and paper and foundries will continue to remain firm while small improvements in demand are forecast for waste water treatment and mining. There is potential for significant growth in road stabilization and, principally, environmental control of water and air pollution. Although growth in the environmental uses appears to be slow to realize, this market offers opportunities to raise the consumption of lime by 25% over the next five years.

The current structure of the lime industry in Canada remains quite concentrated but it may become more fragmented in the next few years as other companies have expressed interest in developing new sources near consumers. Potential producers are likely to offer improved logistics and competitive prices but they may disrupt the market temporarily if it continues to mature. However, the development of new uses could eventually restore the balance in the Canadian market. Lime may be used as an alternative to caustic soda in pulp mills, as feed for precipitated calcium carbonate, or as a stabilizing agent in flue gas scrubbers. In the long term, the market for lime should provide opportunities for growth depending on its acceptance in environmental controls.

PRICES

Canada lime prices quoted in Corpus Chemical Report:	December 1987	December 1988
	($ per tonne)	
Lime, carload and truckload f.o.b. Ontario plant		
High calcium quicklime, bulk	$57.69	63.60
High calcium hydrated lime, bulk	$60.22	66.40

f.o.b. Free on board.

TARIFFS

Item No.	Description	Canada MFN	Canada GPT	Canada USA	United States Canada
2522.10.00	Quicklime	Free	Free	Free	Free
2522.20.00	Slaked lime	Free	Free	Free	Free
2522.30.00	Hydraulic lime	Free	Free	Free	Free

Sources: Customs Tariffs, effective January 1989, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of United States (First Edition Supplement 2) effective January 1, 1989.

TABLE 1A. CANADA, LIME PRODUCTION AND TRADE, 1986 AND 1987

	1986 (tonnes)	1986 ($000)	1987 (tonnes)	1987 ($000)
Production[1]				
By type				
Quicklime	2 069 043^{r}	157 037^{r}	2 140 793	150 971
Hydrated lime	173 534^{r}	14 322^{r}	189 278	16 595
Total	2 242 577	171 359	2 330 071	167 566
By province				
New Brunswick	x	x	x	x
Quebec	x	x	x	x
Ontario	1 511 191	111 567	1 537 582	100 540
Manitoba	x	5 540	x	8 118
Alberta	192 704	16 196	212 943	19 194
British Columbia	123 109	10 339	120 098	9 954
Total	2 242 577	171 359	2 330 071	167 566
Imports				
Quick and hydrated				
United States	44 858	4 307	42 269	3 642
Belgium-Luxembourg	-	-	2 021	409
United Kingdom	2 059	416	-	-
Total	46 917	4 723	44 290	4 051
Exports				
Quick and hydrated				
United States	189 354	16 966	163 627	13 668
Other countries	158	24	140	35
Total	189 512	17 020	163 767	13 703

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Producers' shipments and quantities used by producers.

^{r} Revised; x Confidential; - Nil.

TABLE 1B. CANADA, LIME PRODUCTION AND TRADE 1988P

		1988P	
		(tonnes)	($000)
Production[1]			
By type			
Quicklime		2 330 000	..
Hydrated lime		205 200	..
Total		2 535 200	189 946
By province			
New Brunswick		x	x
Quebec		x	x
Ontario		1 660 000	114 374
Manitoba		x	8 613
Alberta		185 000	17 642
British Columbia		171 000	14 928
Total		2 535 200	189 946
Imports		**(Jan.-Sept.)**	
2522.10	Quicklime		
	United States	17 884	2 369
	Total	17 884	2 369
2522.20	Slaked lime		
	United States	1 910	306
	United Kingdom	1 400	308
	Total	3 310	614
2522.30	Hydraulic lime		
	United States	3 083	505
	Total	3 083	505
Exports			
2522.10	Quicklime		
	United States	65 441	5 683
	South Korea	24	11
	Total	65 465	5 694
2522.20	Slaked lime		
	United States	10 740	1 207
	Total	10 740	1 207
2522.30	Hydraulic lime		
	United States	22 204	2 222
	Bermuda	17	2
	Total	22 221	2 224

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Producers' shipments, and quantities used by producers.

P Preliminary; .. Not available; x Confidential.

TABLE 2. CANADA, LIME PRODUCTION, TRADE AND APPARENT CONSUMPTION, 1970, 1975, 1980-87

	Production[1]					Apparent
	Quick	Hydrated	Total	Imports	Exports	Consumption[2]
			(tonnes)			
1970	1 296 590	224 026	1 520 616	30 649	181 994	1 369 271
1975	1 533 944	199 195	1 733 139	30 099	234 034	1 529 204
1980	2 364 000	190 000	2 554 000	40 901	403 166	2 191 735
1981	2 359 000	196 000	2 555 000	23 144	432 845	2 145 299
1982	2 017 000	180 000	2 197 000	15 963	281 247	1 931 716
1983	2 060 000	166 000	2 232 000	22 844	215 942	2 038 902
1984	2 075 000	174 000	2 249 000	24 848	186 748	2 087 100
1985	2 054 294	157 286	2 211 580	23 056	194 097	2 040 539
1986	2 069 043	173 534	2 242 577	46 917	189 512	2 099 982
1987	2 140 793	189 278	2 330 071	44 290	163 767	2 210 594

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Producers' shipments and quantities used by producers. [2] Production, plus imports, less exports.

TABLE 3. CANADIAN LIME INDUSTRY, 1988

Company	Plant Location	Calcining Capacity	Type of Quicklime
		(000 t/y)	
New Brunswick			
Havelock Lime, division of Dickenson Mines Limited	Havelock	100	High-calcium[2]
Quebec			
Domlim Inc.	St. Adolphe de Dudswell	150	High-calcium[2]
Jolichaux Inc.	Joliette	282	High-calcium[2]
Ontario			
The Algoma Steel Corporation, Limited[1]	Sault Ste. Marie	200	High-calcium and dolomitic
BeachviLime Limited	Ingersoll	922	High-calcium[2]
General Chemical Canada Ltd.[1]	Amherstburg	292	High-calcium
Guelph DoLime Limited	Guelph	122	Dolomitic[2]
Reiss Lime Company of Canada, Limited	Spragge	200	High-calcium
Steetley Quarry Products Inc.	Dundas	345	Dolomitic
Stelco Steel	Ingersoll	215	High-calcium
Timminco Limited[1]	Haley	53	Dolomitic
Manitoba			
The British Columbia Sugar Refining Company, Limited[1]	Fort Garry	16	High-calcium
Continental Lime Ltd.	Faulkner	117	High-calcium
Alberta			
The British Columbia Sugar Refining Company, Limited[1]	Taber	66	High-calcium
Continental Lime Ltd.	Exshaw	130	High-calcium[2]
Summit Lime Works Limited	Hazell	36	High-calcium and dolomitic[2]
British Columbia			
Continental Lime Ltd.	Pavilion Lake	235	High-calcium
BP Resources Canada Limited	Fort Langley	73	High-calcium[2]

[1] Production for captive use. [2] Hydrated lime produced also.

TABLE 4. CANADA, REPORTED CONSUMPTION OF LIME, QUICK AND HYDRATED, 1984-86, (PRODUCERS' SHIPMENTS AND QUANTITIES USED BY PRODUCERS, BY USE)

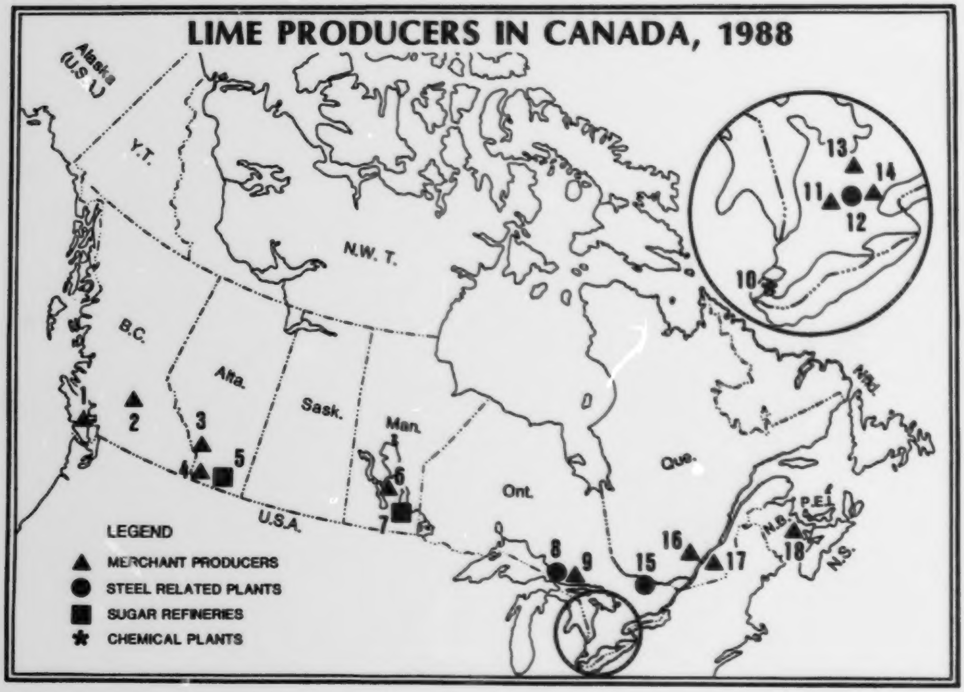
	1984	1985	1986P
		(tonnes)	
Chemical and metallurgical			
Iron and steel plants	954 610	930 610	904 338
Pulp and paper mills[1]	254 803	242 834	286 032
Water and sewage treatment	96 251	118 631	123 344
Nonferrous smelters	83 859	109 321	82 159
Cyanide and flotation mills	36 727	32 174	(2)
Sugar refineries	24 582	11 974	(2)
Other industrial works[3]	528 437	462 579	518 965
Agricultural	17 431	13 945	19 488
Road stabilization	20 229	19 030	(4)
Mining	139 762	95 018	96 515
Other uses	92 309	175 884	212 159
Total	2 249 000	2 212 000	2 243 000

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Excludes consumption of captive produced lime. (2) Confidential figures are included in "other industrial works". [3] Includes glassworks, fertilizer plants, tanneries, sand-lime brick, chemical and uranium plants and other miscellaneous industrial uses. (4) Confidential figures are included in "other uses".
P Preliminary.

TABLE 5. WORLD PRODUCTION OF QUICKLIME AND HYDRATED LIME INCLUDING DEAD-BURNED DOLOMITE SOLD AND USED, 1983-87

	1983	1984	1985	1986P	1987e
			(000 tonnes)		
U.S.S.R.	29 495	29 495	29 195	29 195	29 200
United States	13 520	14 470	14 250	13 150	14 295
Japan[1]	7 435	7 755	7 450	6 715	6 985
West Germany	6 870	6 940	6 845	6 475	5 995
Brazil	4 990	4 585	4 765	4 905	5 000
Poland	4 120	4 250	4 125	4 080	4 080
Mexico	3 630	3 990	3 990	3 945	3 990
Romania	3 620	3 845	3 720	3 720	3 630
East Germany	3 460	3 595	3 565	3 545	3 545
Czechoslovakia	3 100	3 115	3 225	3 330	3 150
France	2 945	3 130	3 100	2 900	2 995
United Kingdom	2 495	2 495	2 495	2 495	2 810
Yugoslavia	2 550	2 585	2 495	2 585	2 585
Italy	2 020	2 400	2 275	2 095	2 305
Canada	2 230	2 280	2 010	2 245	2 270
Belgium	1 770	2 170	1 810	1 765	1 895
Other countries	15 810	16 465	16 460	16 570	16 575
Total	110 060	113 565	111 775	109 715	111 105

Sources: Energy, Mines and Resources Canada; Statistics Canada; U.S. Bureau of Mines, Mineral Commodity Summaries, 1988.
[1] Quicklime only.
P Preliminary; e Estimated.



LIME PRODUCERS IN CANADA, 1988

Alaska (U.S.)
Y.T.
N.W.T.
B.C.
Alta.
Sask.
Man.
Ont.
Que.
Nfld.
P.E.I.
N.B.
N.S.
U.S.A.
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
LEGEND
▲ MERCHANT PRODUCERS
● STEEL RELATED PLANTS
■ SUGAR REFINERIES
* CHEMICAL PLANTS

1. Texada Lime, a division of BP Resources Canada Limited, Fort Langley
2. Continental Lime Ltd., Pavilion Lake
3. Continental Lime Ltd., Exshaw
4. Summit Lime Works Limited, Hazell
5. The British Columbia Sugar Refining Company, Limited, Taber
6. Continental Lime Ltd., Faulkner
7. The British Columbia Sugar Refining Company, Limited, Fort Garry
8. The Algoma Steel Corporation, Limited, Sault Ste. Marie
9. Reiss Lime Company of Canada, Limited, Spragge
10. General Chemical Canada Ltd., Amherstburg
11. Guelph DoLime Limited, Guelph
12. Stelco Steel, Ingersoll
13. Steetley Quarry Products Inc., Dundas
14. BeachviLime Limited, Ingersoll
15. Timminco Limited, Haley
16. Jolichaux Inc., Joliette
17. Domlim Inc., Saint-Adolphe-de-Dudswell
18. Havelock Lime, division of Dickenson Mines Limited, Havelock

Lithium

D.G. FONG

OVERVIEW

The lithium market in 1988 remained strong, with western world consumption of lithium chemicals and metal increasing by about 3% over the 1987 level to reach 27 200 t of lithium carbonate equivalent. The added factors of tight supply and low inventories combined to create price increases at year end for most lithium products. The market improvement stemmed from the strong performance of the aluminum industry, and the strengthening of the traditional end-uses of lithium such as in greases, glass and ceramics. The consumption of lithium batteries, while small in relative terms for the battery market, is growing well particularly in the United States and Japan, and prospects for continued strong growth are excellent.

CANADIAN DEVELOPMENTS

In 1988, Tantalum Mining Corporation of Canada Limited (TANCO) was Canada's sole producer of lithium. TANCO's Bernic Lake mine in Manitoba operated at an annual rate that approached its capacity levels of 15 000 t of spodumene (lithium) concentrate. This mine is also Canada's only producer of tantalum, cesium and rubidium. TANCO is jointly owned by Hudson Bay Mining and Smelting Co., Limited (37.5%), Cabot Corporation (37.5%), and the Manitoba government (25%).

From 1986 to mid-1988, low-iron ceramic-grade spodumene concentrate was produced in the operation's tantalum recovery circuit. Tantalum recovery had been suspended at the end of 1982 owing to depressed market conditions for the metal. TANCO's decision to resume tantalum production in 1988 resulted in an expenditure of $4.7 million to refurbish the mine-mill complex, and to complete the construction of a spodumene plant, allowing for the simultaneous recovery of spodumene and tantalite.

At year-end 1988, TANCO completed a trial run for producing amblygonite concentrate, a higher grade lithium concentrate, as a by-product of the spodumene operation. Potential production capacity of amblygonite concentrate is about 1 500 t/y. While demand for this product at present is small, the company is optimistic about the world market potential for the material by the ceramic industry. The amblygonite concentrate has a lithium content of 8% Li and 25% P_2O_5, compared to the 6.8% Li for the spodumene concentrates.

Other lithium deposits of significant size have been identified over the years in Quebec, Ontario, the Northwest Territories (N.W.T.), and in other parts of Manitoba. The Yellowknife, N.W.T., pegmatite deposit represents the largest Canadian resource. However, it remains unexploited because of its remote location and the expected high start-up costs.

Canada's only other producer, the Quebec Lithium mine of Camsul Inc. near Val d'Or, Quebec, produced spodumene concentrates from 1950 to 1965, when production was suspended due to poor markets. The 1 400 t/d spodumene concentrator was equipped with a chemical plant to produce lithium carbonate. Attempts to reopen the mine in the 1970s with a new process and as an open-pit operation were unsuccessful.

On the product front, Moli Energy Limited of Vancouver commenced production in 1987 of lithium-molybdenum rechargeable batteries at its plant in Maple Ridge, British Columbia. This novel product developed in Canada uses lithium metal as the anode and pure molybdenum disulphide as the cathode to make a new generation of dry cell batteries. The initial production capacity of 1.5 million AA cells a year is expected to rise to about 33 million cells within five years.

INTERNATIONAL DEVELOPMENTS

The United States is the world's largest producer of lithium chemicals and metal. The chemical plants of its two producers, Lithium Corp. of America (Lithco) and Cyprus Specialty Metals Company, operated

---

D.G. Fong is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 992-3951.

at near capacity levels in 1988. Lithco's mine at Bessemer City, North Carolina, produces spodumene concentrate for its nearby chemical plant. The company produces over 70 products, encompassing the full range of lithium applications, including chemicals, industrial compounds, metals and catalysts.

Lithco, a subsidiary of FMC Corporation, also operates a lithium products plant in the United Kingdom, Lithium Corporation of Europe Ltd., which produces organolithium compounds and lithium metal for the European market. Asia Lithium Corporation, Lithco's joint venture with The Honjo Chemicals Company, is the principal outlet for Lithco's products in Japan. Asia Lithium also produces butyllithium and lithium chloride, and is currently building a 100 t/y metal plant which is expected to be in production by July 1989.

In April 1988, Cyprus Minerals Company acquired the lithium operations of Foote Mineral Company, which became part of its subsidiary, Cyprus Specialty Metals Company. The acquisition, which made Cyprus one of the two largest lithium producers in the world, included lithium brine operations in Nevada and Chile, a lithium mine and carbonate plant in North Carolina, and lithium processing plants in Tennessee, Virginia and Pennsylvania.

Cyprus obtains its lithium raw material supplies from the Salar de Atacama deposit in Chile and the Silver Peak operation in Nevada, both of which are brine operations. Cyprus also owns the King Mountain mine in North Carolina which is presently producing small amounts of spodumene concentrate for the glass and ceramic industry. However, the nearby carbonate plant has remained inactive since its closure in 1986.

In 1989, Cyprus plans to increase its production capacity in Chile from the current 8 165 t to 9 070 t of contained lithium. This increase in output is to be accomplished by implementing process improvements at the existing facilities. Cyprus relies on the brine operations as its main supply source because of their lower production costs as compared to hard-rock mines.

The Salar de Atacama brine operation, which commenced production in 1984, is operated by Sociedad Chilena de Litio, Ltda. (SCL), a partnership between Cyprus and the Corporacion de Fomento de la Producción (CORFO). CORFO is an agency of the Chilean government. In June 1988, Cyprus raised its ownership in SCL to 80% from the original 55% through a cash deal with CORFO.

Other major world lithium producers are located in Australia, Zimbabwe, and Namibia. Major deposits are also being evaluated for production in Bolivia and in northern Chile. The U.S.S.R. and the People's Republic of China are known to be major producers, yet little information is available in the west about their lithium industries. Both countries exported lithium chemicals to the west in 1988.

Lithium Australia Ltd., 50% owned by Greenbushes Ltd., produces both a high grade and a glass grade spodumene concentrate from the quarry adjacent to its tantalum-tin mine. The plant located near Bunbury, Western Australia, had been considering producing more down-stream lithium products in association with some major world lithium producers. However, these plans have been deferred indefinitely.

Zimbabwe has long been an important producer and exporter of lithium minerals for the ceramics industry. A number of grades of lepidolite, petolite, pollucite and spodumene are prepared from pegmatite mined at the Al Hyat operation of Bikita Minerals (Pvt) Ltd., a subsidiary of BP Minerals International Ltd. of the United Kingdom. The plant is located at Glen Cova, some 65 km east of Masvingo (formerly Fort Victoria).

USES

The major uses of lithium are in aluminum refining, the production of lithium-based lubricating greases, and the manufacturing of glasses, ceramics and enamels. Lithium chemicals are also used as catalysts in making synthetic rubbers, as an absorber for carbon dioxide in air conditioners, and in sanitizers and pharmaceuticals. Lithium metal is used in high energy lithium batteries where the metal performs as the anode. In addition, the aluminum industry has recently started producing light-weight aluminum-lithium alloys for the aircraft industry.

In aluminum refining, lithium carbonate is used as an additive in the production of aluminum from alumina. The addition of lithium carbonate in the electrolyte pots increases conductivity, lowers power requirements, reduces fluorine emissions and significantly improves production flexibility.

In Canada, the major portion of lithium carbonate consumption goes into the production of aluminum.

Lithium hydroxide is consumed mainly in the production of lithium-soap lubricating greases. Lithium greases, accounting for over 60% of the world's grease market, have superior qualities such as being water resistant, resisting oxidation, and performing well under extremely variable temperatures. These greases are used in automobiles, military equipment, aircraft, as well as in multi-purpose applications.

The addition of lithium to glass and ceramics in the form of spodumene concentrate or lithium carbonate improves the physical properties and the quality of the glass and ceramics. Glass and ceramics containing lithium possess higher strength and lower thermal expansion and are preferred for applications such as thermal-shock-resistant cookwares. The addition of as little as 0.05% lithium can substantially improve production and melting efficiencies of glass and ceramics.

PRICES

Continuing strong demand and tight supply in the lithium market led to price increases in many of the lithium products in 1988. Cyprus and Lithco both raised their prices for most products by an average of 3 to 6%, effective November 1988. The new price for lithium carbonate, technical grade, truckload lots, is quoted at US$3.59/kg, an increase of 17.6¢; lithium hydroxide monohydrate, truckload lots, was up 22¢ to US$4.56/kg; and lithium metal in standard 0.454 t lots, at US$58.86/kg, was up US$2.76/kg.

OUTLOOK

Current known lithium resources, both spodumene and brine operations, are more than adequate to meet demand growth for the foreseeable future. Low cost brine operations are becoming increasingly important supply sources, especially when considering the continued expansion of Chilean brine operations and the potential development of brine deposits in Bolivia.

Growth in demand for lithium is currently projected at 3% a year, part of which is being generated by the glass industry, where lithium is being introduced into container glass, plate glass and fibreglass. As noted, small additions of lithium can significantly improve glass quality and production. Research in the area of lithium addition to glass is continuing to fully harvest the benefits of this technology.

High growth potential is expected in the areas of lithium batteries and of aluminum-lithium alloys for the aerospace industry. In the battery market, a strong growth in demand is projected for the United States and Japan where manufacturers are moving into the replacement or over-the-counter battery market. Prices are likely to remain at a premium because of the superior quality and long shelf-life of lithium batteries. However, increased production volume in the coming years could make lithium batteries very competitive against alkaline batteries.

In the aluminum-lithium alloy sector, producers are making headway in overcoming fabrication and short transverse strength problems. However, the problem of scrap recycling remains to be overcome. In volume terms, consumption in this area could grow substantially as aircraft manufacturers are considering the aluminum-lithium alloys in the main wing and fuselage assemblies. At year end, Boeing Commercial Airplane Co. was reported ready to use a significant portion of these alloys for its 7J7 passenger jet which would represent the first-ever major program for the application of aluminum-lithium alloys. However, major applications of these alloys in the aerospace industry are at least three to five years down the road.

For the Canadian scene, TANCO is likely to retain its position as the sole Canadian lithium producer and supplier of low-iron, high-grade spodumene concentrates for the ceramic and glass industries. A move downstreaming to the lithium carbonate market would face stiff competition from low-cost brine producers.

TARIFFS

Item No.	Description	Canada			United States
		MFN	GPT	USA	Canada
2805	Alkali or alkaline-earth metals; rare-earth metals, scandium and yttrium, whether or not intermixed or inter-alloyed; mercury				
2805.19	-- Other (e.g., cesium, lithium, rubidium)	9.2%	6%	7.3%	5.2%
2825.20	Lithium oxide and hydroxide	Free	Free	Free	2.9%
2825.90.90	Other inorganic bases; other metal oxides, hydroxides and peroxides (e.g., lithium peroxide)	Free	Free	Free	2.9%
2827.39.00	Other chlorides (e.g., lithium chloride)	12.5%	8%	10%	2.9%
2827.59.00	Other bromides and bromide oxides (e.g., lithium bromide)	Free	Free	Free	2.8%
2836.91.00	Lithium carbonates	12.5%	8%	10%	2.9%
2918.15.90	Other salts of citric acid (e.g., lithium citrate)	12.5%	8%	10%	2.9%

Sources: Customs Tariffs, effective January 1989, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States (First Edition Supplement 2) effective January 1, 1989.

TABLE 1A. CANADA, LITHIUM PRODUCTION AND TRADE, 1985-87

	1985		1986		1987	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Production	x	x	x	x	x	x
Imports						
Lithium carbonate						
United States	1 293	6 175	712	3 355	740	3 109
Chile	82	367	204	892	520	2 011
West Germany	1	9	-	-	-	-
Brazil	-	-	36	147	-	-
France	-	-	-	-	...	1
Total	1 375	6 552	953	4 393	1 260	5 120
Lithium hydroxide						
United States	133	688	124	697	177	915
West Germany	-	-	-	-	1	4
United Kingdom	...	1	-	-	...	...
People's Republic of China	17	85	-	-	-	-
Total	150	774	124	697	178	920
Lithium chloride						
United States	28	142	38	208	44	187
United Kingdom	...	...	...	1	-	-
West Germany	-	-	...	...	-	-
Total	28	143	38	210	44	187
Lithium salts of inorganic acids, n.e.s.						
United States	15	79	9	51	21	77
United Kingdom	2	5	2	17	5	14
Australia	1	4	1	3	...	...
Total	17	87	12	72	26	92

Sources: Energy, Mines and Resources Canada; Statistics Canada.
- Nil; ... Amount too small to be expressed; x Confidential; n.e.s. Not elsewhere specified.
Note: Numbers may not add due to rounding.

TABLE 1B. CANADA, LITHIUM PRODUCTION AND TRADE, 1988

Item No.		1988P	
		(tonnes)	($000)
Production		x	x
Exports		(Jan.-Sept.)	
2825.20.00	Lithium oxide and hydroxide		
	United States	3	10
	United Kingdom	11	3
	Total	14	13
2836.91.00	Lithium carbonates	0	0
Imports			
2825.20.00.10	Lithium oxide		
	Australia	43	253
	United States	20	63
	Total	63	317
2825.20.00.20	Lithium hydroxide		
	United States	132	464
	Total	132	464
2836.91.00	Lithium carbonates		
	United States	581	2 225
	Chile	410	1 526
	Total	991	3 751

Sources: Energy, Mines and Resources Canada; Statistics Canada.
P Preliminary; x Confidential.
Note: Numbers may not add due to rounding.

Magnesium

G. COUTURIER

Canada is on the verge of becoming the world's largest producer of magnesium (Mg) metal. If all planned or potential Mg smelting projects are implemented by 1994, total capital investment in this sector could amount to more than $1 billion, creating some 1000 new jobs and producing in excess of 150 000 t/y of Mg metal.

The driving force behind the expanding world demand for magnesium is the automotive sector's need for fabricated parts. According to the International Magnesium Association (IMA), the automotive parts industry is expected to boost its magnesium die-casting applications from an estimated 30 000 t in 1988 to about 55 000 t by 1991.

In 1988, magnesium shipments in the western world were estimated at 250 000 t, an increase of nearly 6% over 1987 shipments of 236 000 t.

The Canada-U.S. Free Trade Agreement (FTA), which came into force on January 1, 1989, will progressively phase-out tariffs on magnesium metal (currently 6.5%) and products (currently 8%) over a ten-year period ending in 1998. This elimination of U.S. tariffs will benefit Canadian magnesium producers.

Timminco Limited, Canada's only producer of primary magnesium, completed a major production rationalization in 1988. Rather than proceeding with its earlier plans to increase its production capacity to 15 000 t/y, Timminco cut its production from 9 000 t/y to 6 000 t/y. Timminco introduced improvements such as the construction of a new prototype vacuum magnesium furnace and the implementation of an automatic crown handling system. These improvements and the conversion to a more efficient gas furnace allowed the company to reduce the plant's workforce by about 100 employees.

Timminco uses the Pidgeon magnesium process in which calcined dolomite is reduced by ferrosilicon in a vacuum retort. The ferrosilicon used in this process is produced by the company in Beauharnois, Quebec, while the dolomite is mined at the plant site at Haley, 100 km west of Ottawa, Ontario.

Canada's newest producer of magnesium metal, Norsk Hydro AS, should have its plant at Bécancour, Quebec, in production by May 1989. The plant, with an initial production capacity of 60 000 t/y, has been designed to allow for future expansions of up to 240 000 t/y. The facility should employ some 350 permanent workers. Although plant construction is proceeding on schedule, the company has reported a cost overrun of approximately 25% above the initial cost estimate of $400 million to build the plant.

In November 1988, Norsk Hydro received its first shipment of 30 000 t of high-grade magnesite feedstock ($MgCO_3$) from the People's Republic of China. Once the Bécancour plant reaches full production capacity, 240 000 t/y of magnesite will be required to sustain the 60 000 t/y magnesium metal production. In 1987, the company decided to postpone its plans to produce MgO from Quebec North Shore dolomite as importing feed material from China proved to be more cost effective. Current plans call for the Bécancour plant to operate at a rate of 40 000 t/y subject to market conditions.

As a result Norsk Hydro modified the front end of its process from the carbochlorination of MgO to a hydrochloric acid leach of magnesite for the production of magnesium chloride brine (MgCl). MgCl brine then undergoes a dehydration stage to produce magnesium chloride prills ($MgCl_2$). Magnesium metal is produced by the reduction of $MgCl_2$ prills in electrolytic cells.

G. Couturier is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 992-3784.

Because trace quantities of dioxins are produced by the Norsk Hydro process, Quebec's Department of the Environment has imposed stringent environmental requirements on Norsk Hydro, setting the limit of dioxin effluents at a maximum of 20 mg/y. To meet this level, the company has indicated it must build an underground tunnel, to collect the effluent, and secondary treatment facilities that are expected to cost up to $50 million.

Also in Quebec, Noranda Minerals Inc. and Lavalin Inc. announced their intention to proceed to the feasibility stage of their Magnola joint-venture project. Prefeasibility study results indicated that magnesium metal production, using asbestos tailings of the Thetford Mines area, would be economic and technically feasible.

The 24-month feasibility study, which will consist of pilot-plant testing of processing and conversion technology developed by the Noranda Technology Centre, is expected to cost some $9 million, with Lavalin undertaking the engineering work. The project will include a $400 000 study on health, safety and environmental impact. Should Magnola go into production, it would require an investment of up to $400 million (1988) and would create about 350 jobs.

In Alberta, the MAGCAN joint venture, formed by Magnesium International Corporation Ltd. (previously referred to as MPLC Holdings S.A.) and Alberta Natural Gas Company Ltd., continued construction of a 12 500 t/y magnesium metal plant at Alderside near High River. Production at the MAGCAN plant could start as early as November 1989 at a rate of 10 000 t/y. Subject to demand, the plant could be expanded in modules of 25 000 t/y to a maximum capacity of 62 500 t/y. At maximum capacity, total investment could approach $375 million, employing some 275 persons. The cost of the first phase of this project (12 500 t/y) is around $100 million and should create 100 jobs.

MAGCAN will utilize the new MPLC process that is claimed to represent a major breakthrough in magnesium production technology. The heart of the process is a single-step reactor that converts magnesite ($MgCO_3$) ore to molten anhydrous magnesium chloride, the basic raw material required for electrolytic reduction to primary Mg metal. The process is reported to consume 15% less power than is required for the production of aluminum. Feed material will be obtained from the Baymag Mines Co. Limited high purity magnesite deposit near Radium Hot Springs, British Columbia, about 300 km from High River.

WORLD

The International Magnesium Association (IMA) reported that for the first nine months of 1988 shipments of primary magnesium in the western world were 189 700 t, an 8.5% increase over the same period in 1987. The IMA also reported that western world production for the first nine months of 1988 reached 178 100 t, an increase of 3.6% over the same period in 1987. On September 30, magnesium inventories were reported to be 27 200 t, a significant reduction over the September 1987 figure of 40 900 t.

The United States, which is the largest magnesium producer in the world, has three primary magnesium plants. The Dow Chemical Company, the largest U.S. producer, operates a 95 000 t/y electrolytic magnesium plant at Freeport, Texas. The magnesium chloride feedstock for the plant is derived from a seawater/dolomite process. The company, which operated at full capacity throughout 1988, intends to reactivate idle electrolytic cells in the first quarter of 1989 adding an extra 5 000 t/y of production. In 1989, Dow's production capability will exceed 1987 levels by more than 20 000 t/y. As a result of a modernization program undertaken in the 1970s and productivity improvements in the early 1980s, Dow's plant is generally regarded as a very competitive operation for Mg metal production.

AMAX Magnesium Corporation operates a primary magnesium plant at Rowley, Utah. This plant, which also utilizes an electrolytic process, has a production capacity of about 38 000 t/y. Magnesium chloride feedstock is normally derived from natural brines of the Great Salt Lake. However, high water levels on the lake in 1986 severely damaged the company's solar ponding system, disrupting raw material supplies. Although the magnesium plant continued to operate with purchased brines, production dropped to about 25 000 t in both 1986 and 1987, rising to 36 000 t in 1988. Following AMAX's July 1987 decision to build a new system of solar evaporation ponds at a cost of some US$20 million, about 25% of the process brine was obtained from its new ponds in 1988, while the remainder was bought from the old Kaiser brine operation at Wendover, near the Nevada border. By the middle of 1989, the company expects to operate almost exclusively with its own Great Salt Lake brine.

However, in August 1988, AMAX decided to sell its magnesium division. According to company officials, magnesium no longer fits into the company's business plan. The selling price, quoted to be around US$55 million, has apparently increased substantially as a result of the strong interest shown by a number of potential buyers.

Northwest Alloys, Inc., a subsidiary of the Aluminum Company of America (Alcoa), operates a magnesium plant at Addy, Washington, which uses the magneterm process whereby magnesium is produced by reducing dolomite with ferrosilicon. Capacity is about 36 000 t/y, however latest reports suggest that the 1988 rate of production was in excess of that level.

Norsk Hydro operates a 60 000 t/y primary magnesium metal plant at Porsgrunn, Norway. Once its Bécancour plant gets on-stream, Norsk Hydro will become the world's largest magnesium producer with a total production capacity of 120 000 t/y. The Porsgrunn plant produces magnesium by the electrolysis of magnesium chloride derived from a seawater/dolomite process and from magnesium chloride brine imported from West Germany.

Similar to the case of its Bécancour plant, Norsk had to prepare a plan to improve effluent treatment at the Porsgrunn plant in the face of tighter environmental standards set by the Norwegian State Pollution Control Authority (SFT). In the interim, the company has had to shut down about 12 000 t/y in production capacity to meet the more stringent dioxin limits. In October 1988 a ruling by SFT ordered Norsk to implement progressive reductions in dioxin effluents of 50% by the end of 1989 to 99.9%-100% by January 1, 1995. The company estimates the cost of complying with a 98.5% dioxin reduction (1993) at US$20 million. As the dioxins effluents must be virtually eliminated by 1995, the final cost will be considerably greater than the $20 million initially budgeted by Norsk Hydro to meet new environmental requirements. As a result of the SFT order, Norsk has limited magnesium production to a level of 40 000 t/y.

In Brazil, Companhia Brasileira de Magnesio (Brasmag), now controlled by Rima Eletrometalurgia S/A, was again forced to modify its previously announced expansion plans due to shortages of electric power. The company had planned to double existing capacity from 6 000 to 12 000 t/y by 1989, and subsequently to increase it to 36 000 t/y by 1992. Brasmag is attempting to capitalize on Brazilian demand for magnesium metal, estimated to be at 10 000 t/y.

Japan Metals & Chemicals Co. Ltd. (JMC) completed construction of a US$15 million primary magnesium plant at Takaoka, in western Honshu. JMC's plant, which utilizes the Magnetherm process, began production in June 1988 at a rate of 3 000 t/y. Dolomite feed will be imported from South Korea. All of the new plant's output will be sold in Japan. The company plans to increase production to 5 000 t/y by 1990.

Production at Societa Italiana per il Magnesio e Leghe di Magnesio's magnesium plant at Bolzano, Italy, was reduced from 12 000 t/y to 3 000 t/y in order to automate part of the production process and to replace the furnaces. The rationalization will reduce the plant's capacity from 15 000 t/y to 10 000 t/y.

Tamil Salt Corporation Ltd., a state owned chemical producer in India, postponed a decision to bring on-stream a new 600 t/y magnesium plant. This plant would be somewhat unique in that it would use sea bittern (the residual brine in salt-works) as its raw material. Also in India, Southern Magnesium and Chemicals Ltd. announced that a 600 t/y magnesium plant will start production by the third quarter of 1989 using the Pidgeon Process.

Elkem A/S, in cooperation with other Norwegian interests and Brasmag of Brazil, has apparently shelved plans to build a new 15 000 t/y magnesium plant at Sauda in Norway.

Queensland Metal Corp. of Australia is considering the construction of a new 30 000 t/y magnesium production facility. In Saudia Arabia, a US$250 000 feasibility study has been undertaken to evaluate the merits of building a primary magnesium metal plant.

PRICES

Magnesium inventories in 1988, were particularly low, creating an upward pressure on prices. Inventories were reported to be at less than two months supply for most of 1988 compared to a 6-month supply in 1987. Die-casting alloys moved up in price from US$1.33 to $1.43/lb., while primary ingots increased from US$1.53 to $1.63/lb.

The growth in demand for magnesium metal and products was particularly strong in the die-casting and steel-desulphurization sectors, while consumption remained strong in aluminum alloying applications.

Magnesium prices in Europe, reached a level of DM 760-770 per 100 kg in 1988, equivalent to about US$2.00/lb. The main factor behind this rise was the 12 000 t/y production cutback at the Norsk Hydro Porsgrunn plant. While Norsk Hydro has met its regular customers' requirements, it has had to withdraw completely from the spot market.

Since the specific gravity of magnesium is only two-thirds that of aluminum, magnesium remains competitive on a volume basis as long as its price does not exceed 1.5 times the price of aluminum. At the current magnesium selling price of US$1.43/lb. for die-casting applications, versus US$1.00/lb. for aluminum (last six months of 1988), magnesium is a very attractive metal where cost, weight and strength are important considerations.

CONSUMPTION AND MARKETS

The largest single application for magnesium, accounting for over 50% of non-socialist consumption in 1987, is as an alloying agent with aluminum. Aluminum/magnesium alloys have greater tensile strength, increased hardness, better welding properties and superior corrosion resistance than unalloyed aluminum. One of the most important applications for aluminum/magnesium alloys has been in beverage cans, which contain about 1.9% magnesium. With increased recycling of can scrap in recent years, magnesium consumption for this application showed almost no growth from the 1985 consumption level of 121 000 t.

The second largest use of magnesium is in structural applications, of which pressure die-cast products constitute the most important use. Die-casting applications increased from 21 000 t in 1982 to an estimated 30 000 t in 1988 and are expected to reach 55 000 t in 1991.

Magnesium die-casting has a number of advantages over aluminum such as its lower heat of solidification, thereby increasing die-casting production capacity by approximately 25%, resulting in major process energy savings. In addition, magnesium dies are reported to last as much as two times longer than aluminum dies. Some die-casters note that even at a magnesium-aluminum price ratio of 1.7:1, magnesium metal parts can be fabricated at the same cost as those made of aluminum.

In response to concerns about corrosion, magnesium producers have undertaken extensive research and developed new applications for high-purity magnesium alloys that were once considered too corrosive for the metal. Major applied research projects are also under way in Europe, such as under the auspices of the EEC sponsored program for European Research on Advanced Materials (EURAM). Rapid solidification of magnesium alloys and novel alloys are some of the projects currently being sponsored.

As automobile manufacturers increase the fuel efficiency of their fleets, the use of lightweight parts including those of die-cast magnesium will be of increasing importance. Some of the potential automotive applications for magnesium are in transmission and transfer cases, clutch housings, intake manifolds, wheel rims, covers for grills, air cleaners, valves and engine blocks.

However, with current low prices and stable supplies of oil, there is very little incentive for the U.S. government to introduce more stringent Corporate Average Fuel Economy (CAFE) requirements. The CAFE requirements were enacted by Congress as part of the 1975 Energy Policy and Conservation Act. Due to additional costs, many car manufacturers have been reluctant to switch from conventional metals such as steel to lighter metals, though major automobile weight reductions were made in the period following the 1973 oil crisis up to the early 1980s.

Aside from automotive applications, die-cast magnesium products are widely used in the manufacture of portable tools and sports equipment. Magnesium use in electronic equipment, particularly in computer housings and components, has grown substantially and this trend is expected to continue. Besides its good strength to weight ratio, magnesium is preferred for these applications because it dissipates heat well and it also confines the electromagnetic and radio frequency interference. Chicago White Metal is currently producing die-casting components for computer makers such as International Business Machines Corporation (IBM) and NCR Corporation.

Magnesium is also used as a deoxidizing and desulphurizing agent in the ferrous industry. Magnesium demand in this application, which has grown from about 8 400 t in 1982 to an estimated 25 000 t in 1988, is expected to expand to 38 000 t/y by 1991.

The metal is also used to produce ductile or nodular iron and as a reducing agent in the production of titanium, zirconium and other reactive metals. Pure magnesium metal is used frequently for cathodic corrosion protection of steel structures, especially underground pipes and tanks.

Potential new applications for magnesium that are currently being investigated include magnesium/alumina, magnesium/silicon carbide and magnesium/graphite composite castings, hydrogen storage systems utilizing magnesium hydride, and a magnesium-sulphuric acid battery.

OUTLOOK

During the next decade it is expected that overall magnesium consumption will grow at an average annual rate of 3.5%. More extensive use of magnesium parts is expected particularly in sport and luxury cars and in light trucks and vans.

By the end of 1989, western world magnesium production capacity will grow by 70 000 t/y over the 1988 level of 260 000 t/y. Markets are expected to be particularly tight until the second quarter of 1989, when the Bécancour plant comes on-stream. For the second half of 1989, demand should continue to be strong as producers replenish low inventories, which were at 1.3 months supply at the end of September 1988.

In view of increased competition in world magnesium markets, prices for magnesium metal during the 1990s should be somewhat less in constant dollars than current prices of US$1.63/lb. for primary ingots and US$1.43/lb. for die-casting alloy. Given the large amount of new production capacity that is coming on-stream in the early 1990s, a major rationalization could occur in the industry, whereby high-cost producers could be forced out of business.

The future for magnesium is directly related to its competitiveness with aluminum, particularly in the context of pricing. The implementation of world class projects, such as Norsk Hydro at Bécancour, should provide the magnesium industry with the credibility needed to assure stable supply for the development of new markets. If magnesium producers could sustain a long term magnesium-aluminum price ratio of around 1.5, a number of new die-casting applications for magnesium could result. However, some potential users have inferred that they would only convert from aluminum to magnesium if they could obtain the 30% weight savings at no additional cost to the final product. With its competitive advantages of inexpensive and abundant energy, new and efficient technology, readily available feed material and proximity to the U.S. market, over the next few years Canada can expect to become a key player in the world's magnesium industry.

Item No.	Description	Canada MFN	Canada GPT	Canada USA	United States Canada	EEC MFN	Japan[1] MFN
81.04	Magnesium and articles thereof, including waste and scrap						
	-Unwrought magnesium:						
8104.11.00.00	--Containing at least 99.8% by weight of magnesium	4%	2.5%	3.6%	7.2%	5.3%	6.5%
8104.19.00.00	--Other	4%	Free	3.6%	5.8%	5.3%	6.5%
8104.20.00.00	--Waste and scrap	Free	Free	Free	Free	Free	3.2%
8104.30	-Raspings, turnings and granules, graded according to size; powders						
8104.30.10.00	---Raspings, turnings and granules; powders, alloyed	10.2%	6.5%	9.1%	5.8%	5.3%	7.2%
8104.30.20.00	---Powders, not alloyed	4%	2.5%	3.6%	5.8%	5.3%	7.2%
8104.90	-Other						
8104.90.10	---Bars, rods, plates, sheets, strip, foil, tubes and pipes, alloyed	4%	Free	3.6%	3.1%	5.3%	7.2%
8104.90.10.10	-----Bars and rods	4%	Free	3.6%	3.1%	5.3%	7.2%
8104.90.10.20	-----Plates, sheets, strip, foil, tubes and pipes	4%	Free	3.6%	3.1%	5.3%	7.2%
8104.90.90	---Other	10.2%	6.5%	9.1%	3.1%	5.3%	7.2%
8104.90.90.10	-----Structural shapes	10.2%	6.5%	9.1%	3.1%	5.3%	7.2%
8104.90.90.90	-----Other	10.2%	6.5%	9.1%	3.1%	5.3%	7.2%

Sources: Customs Tariffs, effective January 1989, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States (First Edition, Supplement 2) effective January 1, 1989; Official Journal of the European Communities, Vol. 30, No. L256, 1987, "Conventional" column; Custom Tariff Schedules of Japan, 1988.

[1] GATT rate is shown, lower tariff rates may apply circumstantially.

TABLE 1. CANADA, CONSUMPTION[1] OF MAGNESIUM, 1981-87

	1981	1982	1983	1984	1985	1986	1987
				(tonnes)			
Castings and wrought products[2]	619	574	490	550	453	633	517
Aluminum alloys and other uses[3]	5 768	4 431	5 078	6 296	6 129	6 098	5 881
Total	6 387	5 005	5 568	6 846	6 582	6 731	6 398

[1] Available data, as reported by consumers. [2] Die, permanent mould and sand castings, structural shapes, tubing, forgings, sheet and plate. [3] Cathodic protection, reducing agents, deoxidizers and other alloys.

TABLE 2. CANADIAN IMPORTS/EXPORTS OF MAGNESIUM METAL, 1980-87

	Imports	Exports
	(tonnes)	
1980	3 419	5 316
1981	3 249	6 221
1982	1 972	4 501
1983	3 714	2 500
1984	4 287	4 022
1985	3 926	4 730
1986	3 419	4 729
1987	2 905	4 571

Source: Statistics Canada.

TABLE 3. WORLD PRIMARY MAGNESIUM PRODUCTION, 1982-87

	1982	1983	1984	1985	1986P	1987e
			(000 tonnes)			
Canada	7.9	6.0	8.0	7.0	8.2	7.0
United States	89.9	104.7	144.4	135.9	117.9	124.4
U.S.S.R.	77.0	80.0	85.0	85.0	85.3	90.0
Norway	35.9	29.9	48.3	54.7	56.5	50.0
France	9.6	10.9	12.8	13.8	13.8	14.0
Italy	9.9	9.8	8.2	7.9	9.1	11.0
China, People's Republic	7.5	8.5	8.5	9.0	9.1	7.0
Japan	5.6	6.0	7.1	8.4	9.1	8.2
Yugoslavia	4.2	4.7	5.1	4.9	4.5	4.5
Poland	0.5	-	-	-	-	-
Brazil	0.3	0.5	1.2	2.6	4.5	5.8
India	0.1	0.1	0.1	0.1	0.1	0.1
Total	248.4	261.1	328.7	329.1	318.1	322.0

Source: American Bureau of Metal Statistics.
P Preliminary; e Estimated; - Nil.

TABLE 4. PRIMARY MAGNESIUM PRODUCTION BY WORLD ZONE[1], 1980-88

Period	Area 1 United States and Canada	Area 2 Latin America	Area 3 Western Europe	Area 5 Asia and Oceania	Total
			(000 tonnes)		
1980	163.0	-	64.4	9.2	236.6
1981	138.4	-	64.4	5.7	208.5
1982	97.8	-	52.8	5.8	156.4
1983	109.0	-	51.0	6.0	166.0
1984	152.8	1.0	71.6	6.7	232.1
1985	142.9	2.0	80.8	8.2	233.9
1986	130.7	3.7	81.4	8.1	223.9
1987	133.2	5.2	84.0	7.9	230.3
1988 (Jan.-Sept.)	110.1	4.3	57.4	6.3	178.1

Source: International Magnesium Association.

[1] There is no production in Area 4, Africa and the Middle East.

- Nil.

TABLE 5. PRIMARY MAGNESIUM SHIPMENTS BY WORLD ZONE, 1980-88

Period	Area 1 United States and Canada	Area 2 Latin America	Area 3 Western Europe	Area 4 Africa and Middle East	Area 5 Asia and Oceania	Area 6 Other	Total
			(000 tonnes)				
1980	111.0	17.0	66.0	2.0	23.0	-	219.0
1981	104.0	12.0	61.0	2.0	24.0	-	203.0
1982	85.8	8.3	60.6	1.3	17.7	-	173.7
1983	98.6	9.6	60.4	2.4	33.4	-	204.4
1984	110.1	8.0	66.8	1.6	29.5	-	216.0
1985	102.4	9.4	72.2	2.4	38.4	-	224.8
1986	103.3	11.3	73.6	3.2	35.0	-	226.4
1987	113.7	8.3	66.9	5.2	28.7	13.2	236.0
1988 (Jan.-Sept.)	94.3	9.1	51.4	3.4	26.0	5.5	189.7

Source: International Magnesium Association.

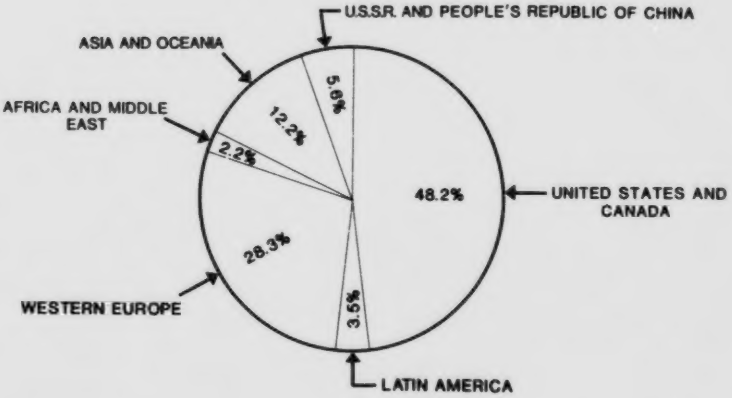
- Nil.

TABLE 6. PRIMARY MAGNESIUM SHIPMENTS BY WORLD ZONE AND CATEGORY, 1987

Use	Area 1 United States and Canada	Area 2 Latin America	Area 3 Western Europe	Area 4 Africa and Middle East	Area 5 Asia and Oceania	Area 6 Other	Total
			(000 tonnes)				
Aluminum alloying	58.6	2.6	36.2	5.2	19.5	-	122.1
Nodular iron	5.2	0.8	6.1	-	2.1	-	14.2
Desulphurization	16.0	-	5.8	-	0.1	-	21.9
Metal reduction	6.0	0.3	2.4	-	0.1	-	8.8
Electro-chemical	6.3	0.5	0.4	-	0.8	-	8.0
Chemical	1.8	-	3.0	-	2.4	-	7.2
Die-casting	11.3	3.9	9.3	-	2.1	-	26.6
Gravity casting	0.7	-	0.6	-	0.5	-	1.8
Wrought products	6.9	-	1.3	-	0.2	-	8.4
Other	0.9	0.2	1.8	-	0.9	13.2	17.0
Total	113.7	8.3	66.9	5.2	28.7	13.2	236.0

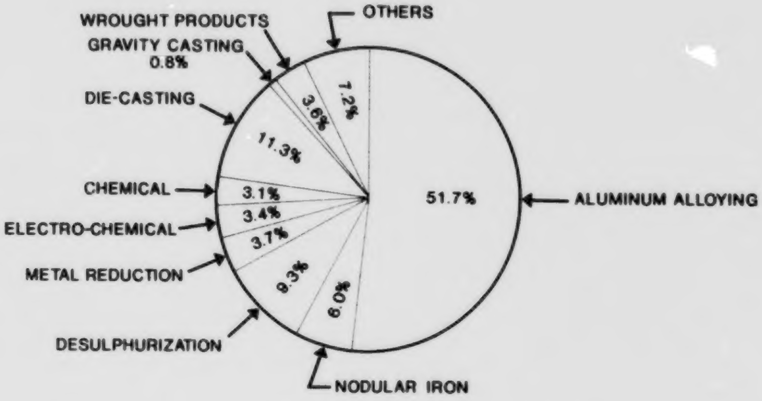
Source: International Magnesium Association.
- Nil.

PERCENTAGE OF MAGNESIUM METAL
Shipments by World Zone 1987



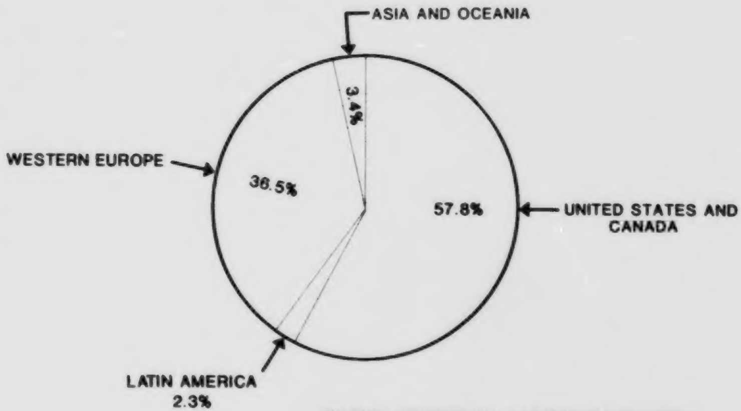
SOURCE: INTERNATIONAL MAGNESIUM ASSOCIATION

PERCENTAGE OF MAGNESIUM SHIPMENTS
By Use in 1987



SOURCE: INTERNATIONAL MAGNESIUM ASSOCIATION

PERCENTAGE OF MAGNESIUM METAL
Production by World Zone 1987



SOURCE: INTERNATIONAL MAGNESIUM ASSOCIATION

Mineral Aggregates

O. VAGT

Following the recovery of Canada's economy since the 1982-84 recessionary period, construction expenditures related particularly to residential building expanded rapidly. The commercial and institutional building sectors expanded to a lesser extent, however expenditures related to engineering construction, with gas and oil facilities accounting for up to one-third, continued relatively low until the broader upturn in 1988.

Demand for mineral aggregates generally reflects the trends in construction, and from a regional perspective, engineering-related construction was particularly strong in Quebec, Ontario and Alberta during 1988. Total aggregate production over the past three years has been in excess of 350 Mt/y. Average unit prices have not changed greatly and continue to fluctuate widely from province to province depending upon the proximity of consuming centre. Housing starts, a fair indicator of demand for construction materials, rose to 245 986 in 1987 and decreased to about 220 000 in 1988. Total construction expenditures are expected to exceed $80 billion.

Several provincial programs continued to assess aggregate resources and future market requirements. In some instances these programs have been undertaken as part of Mineral Development Agreements under the Economic and Regional Development Agreements (ERDA's) between the federal and provincial governments. The inherent constraints to development of aggregate properties persist as property owners oppose the development of nearby quarries or gravel pits. Awareness of the importance of mineral aggregates to the construction industry has been heightened in recent years and in the case of Ontario a new Planning Act addresses the problem.

Policy Statement

A policy statement issued in May 1986 by the Government of Ontario emphasizes the need for wise use of aggregate resources. It is expected that existing pits and quarries will be protected, and that planning at the municipal level will protect unopened deposits from incompatible land uses.

CANADIAN DEVELOPMENTS

Sand and Gravel

Sand and gravel deposits are widespread and large producers have established "permanent" plants as convenient as possible to major consuming centres. In addition to large aggregate operations usually associated with other construction-related activities such as ready-mix or asphalt plants, many small producers active on a seasonal or part-time basis serve local markets. Even relatively large operations may operate intermittently serving when required as a supply arm for a heavy construction company. Provincial departments of highways operate regional or divisional quarries supplying roadbed material for new and repair work. Varied exploitation by a wide range of groups has resulted in obstacles to the collection of accurate production and consumption data concerning sand, gravel and stone.

Crushed Stone

Many stone-producing operations are part-time or seasonal, others are operated as subsidiaries of construction or manufacturing establishments not classified to the stone industry. Also, some are operated by municipal or provincial government departments producing stone for their own direct use. Quarries removing rock by drilling, blasting and crushing generally are not operated for small, local needs as often occurs in the case of gravel pits. Rather, these operations are generally associated with large construction-related companies. Depending on costs and availability, crushed stone competes with gravel and crushed gravel as an aggregate in concrete and asphalt, and as railway ballast and road metal. In these applications it is subject to the same physical and chemical testing procedures as the gravel and sand aggregates.

O. Vagt is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 992-2667.

Quarrying operations for supplying high-quality construction aggregates or high chemical quality stone have been successful on both the east and west coasts where large-volume ocean transportation facilities may be used to reduce unit transportation costs. Producers of high-calcium limestone on Texada Island in British Columbia have supplied Vancouver and Washington state cement and lime producers with raw material for many years. Construction aggregate from the Strait of Canso area in Nova Scotia has been barged to many Atlantic Canada areas and during the last four years it has been shipped as far as Houston, Texas in 50 000 to 60 000 t shiploads.

The Newfoundland Resources & Mining Company Limited, owned by Explaura Holdings PLC of the United Kingdom, continued development of its limestone aggregate operation on the Port-au-Port Peninsula, Newfoundland. Start-up is planned in mid-1989 with large-scale bulk shipments mainly to U.S. markets gradually increasing to 4-5 Mt/y in 3-5 years.

WORLD DEVELOPMENTS

Large scale on-shore quarrying of normal aggregates to serve international needs was pioneered in 1986 by Foster Yeoman Ltd. at its Glensanda quarry on the west coast of Scotland. Major 1988-89 projects under way include Vulcan Materials Co.'s joint venture on the Yucatan Peninsula, Mexico and The Newfoundland Resources & Mining Company's project on the Port-au-Port Peninsula, as described previously.

Trends in major foreign investment during the past three years, particularly by British companies in the U.S. aggregates industry, have been remarkable. Major companies involved include: ARC Ltd., Tarmac plc, RMC Group plc, Redland plc, C.H. Beazer and English China Clays plc. The potential for corporate growth in a country characterized by less concentration, along with the opportunity to diversify geographically because of the cyclical nature of construction, are seen as important motivating factors for these developments.

Offshore dredging projects have become more important in recent years as a result of strong demand for aggregates and on-land environmental and zoning constraints. This is particularly true in the United States, a main source for western Europe's marine aggregates, and Japan, where seabed sands account for about 40% of the total domestic production of fine aggregate necessary for concrete.

Lightweight Aggregates

Four categories generally used to classify the lightweight aggregates combine elements of source, processing methods and end-use. Natural lightweight aggregates include materials such as pumice, scoria, volcanic cinders and tuff. Manufactured lightweights are bloated or expanded products obtained by heating certain clays, shales and slates. Ultra-lightweights are made from natural mineral ores, such as perlite and vermiculite, which are expanded or exfoliated by the application of heat and used mainly for insulation and horticultural needs. Fly ash obtained from the combustion of coal and coke, and slag resulting from metallurgical processes, are classed as by-product aggregates.

Perlite: Perlite is a variety of glassy volcanic rock (obsidian) that contains 2 to 6% of chemically combined water. When the crushed rock is heated rapidly to 760°C-980°C expansion occurs between 4 and 20 times its original volume. With attention being given to preblending of feed to the kiln and retention time in the kiln, expanded material can be manufactured to weigh as little as 30 to 60 kg/m^3.

In Canada, imported perlite is expanded and used mainly for fibre-perlite construction products, where its value as a lightweight material is augmented by its fire-resistant qualities. It is also used as a loose insulation and as an insulating medium in concrete products. Perlite, vermiculite, and expanded shale and clay are becoming more widely used in agriculture as soil conditioners and fertilizer carriers.

Imports of crude perlite for consumption in Canada are from New Mexico and Colorado deposits, worked by companies including Manville Corporation, USG Corporation, United Perlite Corp. and Grefco, Inc.

Aurun Mines Ltd., a perlite producer from a deposit near Clinton, British Columbia, was placed in receivership in late 1988. The processing plant in Surrey, British Columbia, is operated by an associate producing horticultural grades from imported raw material. With improved markets for a wider range of grades there is optimism that high-quality domestic sources will be used in the future.

Pumice: In Canada, a number of concrete products manufacturers use pumice imported from Greece or from the northwestern United States, mainly in the manufacture of concrete blocks. A major potential use for pumice in Canada relates to highway surfacing whereby exceptional skid resistance is imparted by the angular faces of this aggregate.

Vermiculite: The term vermiculite refers to a group of micaceous minerals, hydrous magnesium-aluminum silicates, that exhibit a characteristic lamellar structure and expand or exfoliate greatly when heated rapidly.

Canadian consumption is mainly for horticulture with lesser amounts for insulation and miscellaneous uses.

The major producer of vermiculite is the United States. The principal company supplying Canada is W.R. Grace and Company, from operations at Libby, Montana and from the Enoree region of South Carolina. Canada also imports crude vermiculite from the Republic of South Africa, where Palabora Mining Co. Ltd. (PMC) is the major producer.

Vermiculite occurrences have been reported in British Columbia, and deposits near both Perth and Peterborough in Ontario have been investigated.

Clay, shale and slag: Common clays and shale are used throughout Canada for manufacturing lightweight aggregates. Although the Canadian industry began in the 1920s in Ontario, it did not evolve significantly until the 1950s when it grew in support of demand from the construction industry. Raw materials are usually quarried adjacent to the plant sites. Clays receive little beneficiation other than drying before introduction to the kiln where they are heated to promote expansion. Shales are crushed and screened before burning.

In steelmaking, iron ore, coke and limestone flux are melted in a metallurgical process. When completed, lime is combined with the silicates and aluminates of the ore and coke, forming slag, a nonmetallic product. After controlled cooling from the molten state, the porous, glassy slag may be crushed and sized for many construction-related applications.

On-going research sponsored through CANMET and relating to supplementary cementing materials led to the successful use of blast furnace slag for manufacturing a slag cement. Reiss Lime Company of Canada, Limited is now producing this type of cement from a grinding plant at Spragge, Ontario, using granulated slag from The Algoma Steel Corporation, Limited, Sault Ste. Marie plant. Plant capacity is 200 000 t/y of slag cement for complete or partial replacement of Portland cement, depending on requirements. The primary use at present is in mine backfill, however, construction-related uses are also being investigated.

PRICES

There are no standard prices for sand, gravel and crushed stone. In addition to supply-demand factors, prices are determined regionally, or even locally, by production and transportation costs, by the degree of processing required for a given end use and by the quantity of material required for a particular project.

USES

The principal uses for sand and gravel are in highway construction and as concrete aggregate. Individual home construction triggers the need for about 300 t of aggregate per unit while apartment construction requires only about 50 t per unit, according to an Ontario Ministry of Natural Resources study.

The construction industry utilizes 95% of total stone output as crushed stone mainly as an aggregate in concrete and asphalt, in highway and railway construction and as heavy riprap for facing wharves and breakwaters. Specifications vary greatly, depending on the intended use, and many tests are required to determine the acceptability of aggregates for certain applications. Particle size distribution of aggregates, as assessed by grading tests or sieve analysis, affects the uniformity and workability of a concrete mix as well as the strength of the concrete, the density and strength of an asphalt mix, and the durability, strength and stability of the compacted mass when aggregates are used as fill or base-course material. Of importance also are tests to determine the presence of organic impurities or other deleterious material, the resistance of the aggregate to abrasion and to freeze-thaw cycles, the effects of thermal expansion, absorption, porosity, reactivity with associated materials and surface texture.

The use of lightweight concrete in commercial and institutional projects has facilitated the construction of taller buildings and the use of longer clear spans in bridges and buildings. Additional advantages from the use of lightweight aggregates lie in the fact that they supply thermal and acoustical insulation, fire resistance, good freeze-thaw resistance, low water absorption and a degree of toughness to the concrete product.

There are as yet no Canadian Standards Association (CSA) specifications for the lightweight aggregates. Production and application are based on the American Society for Testing and Materials (ASTM) designations as follows: ASTM Designations C 332-66 - Lightweight Aggregates for Insulating Concrete; C 330-75a - Lightweight Aggregates for Structural Concrete; and C 331-69 - Lightweight Aggregates for Concrete Masonry Units.

OUTLOOK

Although the level of economic activity is expected to drop in 1989, the outlook for the building construction sector is positive providing interest rate and consumer price increases are not excessive. Projections in late 1988 by the Conference Board of Canada suggest that GDP will expand 3% in 1989 and 2.7% in 1990. Housing starts are expected to decline - particularly in Ontario and Quebec - and starts nationwide may be at a more sustainable level of 180-200 000 in 1989. Energy-related investments may continue to recover and this would broaden construction activity in western Canada. Repetition of the 1988 drought, which contributed to weaker housing in Saskatchewan and Manitoba, could reduce overall growth to little more than 2%. Megaprojects such as Hibernia, if full approvals are given, are expected to provide a boost to the energy sector beginning in 1990-91.

The Canadian Construction Association predicts growth in constant dollar expenditures of about 4% through the 1987-96 period in the non-residential contract construction industry.

Urban expansion has greatly increased demand for aggregates in support of major construction. Paradoxically, urban spread has not only tended to overrun operating pits and quarries, but has extended into areas containing potentially valuable reserves. Further complications have arisen in recent years as society has become increasingly aware of environmental problems, thus emphasizing that operators may face additional constraints when expanding or establishing new plants. Clearly, municipal and regional zoning must be designed to regulate toward the best utilization of resources, along with rehabilitation of sites to ensure optimal sequential land use.

Sand and gravel will continue to be competitive with crushed stone in many areas and, in some applications, with lightweight aggregates. New reserves must be located and assessed as part of the community planning or regional zoning process. Prices for aggregates will continue to rise with increasing land values, more sophisticated operating techniques and equipment, reduction of readily-accessible reserves and added rehabilitation expenditures.

Estimates have indicated that available sand and gravel supplies in some regions will be depleted by the 1990s making outlying deposits necessary for the needs of the construction industry. Predicted shortages could encourage exploitation of offshore deposits and even underground mining in some regions.

TABLE 1. CANADA, TOTAL PRODUCTION OF STONE, 1986-88

	1986		1987		1988P	
	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)
By province[1]						
Newfoundland	476	2 712	931	8 535	990	9 158
Nova Scotia	4 023	21 944	4 437	23 133	4 450	22 695
New Brunswick	2 344	13 064	2 878	15 934	2 960	16 280
Quebec	36 066	172 194	42 731	213 112	43 007	217 762
Ontario	45 477	226 130	52 412	273 032	51 000	280 500
Manitoba	4 100	26 831	3 760	15 959	3 500	14 000
Saskatchewan	-	-	2	4	2	4
Alberta	229	1 315	249	1 532	300	2 100
British Columbia	4 403	23 049	5 213	29 544	4 913	34 388
Northwest Territories and Yukon	484	1 416	678	2 165	1 300	4 425
Canada	97 602	488 655	113 291	582 950	112 422	601 312
By use[2]						
Dimensional stone						
Rough	154	11 542	..	..	..	..
Monumental and ornamental stone (n.f.)	74	8 405	..	..	..	..
Other (flagstone, curbstone, paving blocks, etc.)	28	2 203	..	..	..	..
Chemical and metallurgical						
Cement plants, Canada	11 535	23 315	..	..	..	..
Cement plants, foreign	468	1 316	..	..	..	..
Lining, open-hearth furnaces	-	-	..	..	..	..
Flux in iron and steel furnaces	1 065	4 401	..	..	..	..
Flux in nonferrous smelters	62	1 445	..	..	..	..
Glass factories	190	3 423	..	..	..	..
Lime plants, Canada	3 556	18 288	..	..	..	..
Lime kilns, foreign	396	1 740	..	..	..	..
Pulp and paper mills	240	1 903	..	..	..	..
Sugar refineries	32	159	..	..	..	..
Other chemical uses	617	3 967	..	..	..	..
Pulverized stone						
Whiting (substitute)	32	1 938	..	..	..	..
Asphalt filler	108	657	..	..	..	..
Dusting, coal mines	6	188	..	..	..	..
Agricultural purposes and fertilizer plants	1 122	13 532	..	..	..	..
Other uses	243	9 887	..	..	..	..
Crushed stone for						
Manufacture of artificial stone	17	413	..	..	..	..
Roofing granules	358	6 644	..	..	..	..
Poultry grit	58	2 300	..	..	..	..
Stucco dash	3	212	..	..	..	..
Terrazzo chips	4	134	..	..	..	..
Rock wool	-	-	..	..	..	..
Rubble and riprap	1 651	9 654	..	..	..	..
Concrete aggregate	11 966	61 400	..	..	..	..
Asphalt aggregate	8 169	37 520	..	..	..	..
Road metal	41 044	174 808	..	..	..	..
Railroad ballast	3 247	19 025	..	..	..	..
Other uses	26 249	109 840	..	..	..	..
Total	112 693	530 258	..	..	..	..

[1] Data exclude stone used in the Canadian cement and lime industries. [2] Data include stone used in the Canadian cement and lime industries.
P Preliminary; .. Not available; - Nil; n.f. Not finished or dressed.
Totals may not add due to rounding.

TABLE 2. CANADA, PRODUCTION OF SAND AND GRAVEL BY PROVINCE, 1986-88

	1986		1987		1988^{p}	
	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)
Newfoundland	2 343	11 112	3 319	16 451	3 440	16 856
Prince Edward Island	501	1 754	673	2 541	700	2 625
Nova Scotia	7 889	22 064	8 334	24 368	9 600	33 600
New Brunswick	8 982^{r}	X	11 056	X	10 300	X
Quebec	29 607	X	36 460	X	33 089	X
Ontario	87 666^{r}	248 234^{r}	96 251	280 725	99 650	288 985
Manitoba	13 050	35 752	14 687	39 264	13 300	37 240
Saskatchewan	14 189	31 509	11 922	33 619	10 500	30 975
Alberta	45 149^{r}	133 199^{r}	44 050	137 523	42 500	133 875
British Columbia	42 413^{r}	103 812^{r}	49 260	131 316	49 300	133 110
Yukon and Northwest Territories	5 888	16 635	2 535	9 634	3 685	15 030
Canada	257 677^{r}	677 250^{r}	278 546	768 755	276 064	782 675

^{p} Preliminary; X Confidential; ^{r} Revised.
Totals may not add due to rounding.

TABLE 3. AVAILABLE DATA ON CONSUMPTION OF SAND AND GRAVEL, BY PROVINCE, 1985 AND 1986

		Atlantic Provinces	Quebec	Ontario	Western Provinces[1]	Canada
				(000 tonnes)		
Roads	1985	15 932	19 897	42 623	86 648	165 100
	1986	14 032	17 522	46 348	83 243	161 145
Concrete aggregate	1985	1 598	4 397	15 921	11 703	33 619
	1986	1 703	4 179	17 574	11 347	34 803
Asphalt aggregate	1985	1 600	3 055	4 951	7 618	17 224
	1986	1 553	2 876	5 081	9 398	18 908
Railroad ballast	1985	87	442	520	4 043	5 092
	1986	372	130	123	2 430	3 055
Mortar sand	1985	80	198	1 368	427	2 073
	1986	86	269	1 583	356	2 294
Backfill for mines	1985	...	211	989	562	1 761
	1986	28	936	1 043	592	2 599
Other fill	1985	1 631	4 295	9 341	12 459	27 726
	1986	1 613	3 497	13 896	8 124	27 130
Other uses	1985	235	25	2 083	1 245	3 588
	1986	328	198	2 018	5 198	7 742
Total sand and gravel	1985	21 162	32 520	77 796	124 705	256 183
	1986	19 716	29 607	87 666	120 689	257 677

[1] The western provinces include the Yukon and Northwest Territories.
... Amount too small to be expressed.
Totals may not add due to rounding.

TABLE 4. CANADA, EXPORTS AND IMPORTS OF SAND AND GRAVEL AND CRUSHED STONE, 1985-87

	1985		1986		1987	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Exports						
Sand and gravel						
United States	234 883	921	249 566	925	392 092	1 692
South Africa	1 854	14	36	10	18	5
Algeria	-	-	-	-	-	-
France	65	11	133	46	127	78
St. Pierre and Miquelon	-	-	19	2	19	2
Other countries	4 988	33	79	14	22 291	695
Total	241 790	979	249 833	997	414 547	2 472
Crushed limestone						
United States	1 195 939	6 550	1 340 394	7 487	1 709 476	9 480
Other countries	-	-	9 951	66	7	1
Total	1 195 939	6 550	1 350 345	7 553	1 709 483	9 481
Imports						
Sand and gravel, n.e.s.						
United States	1 109 425	5 380	1 046 574	5 396	1 264 482	7 191
West Germany	846	3	135	2	1 537	6
Other countries	1 530	24	480	17	2 373	47
Total	1 111 801	5 408	1 047 189	5 415	1 268 392	7 244
Crushed limestone						
United States	2 071 651	10 889	2 354 276	13 095	2 691 937	12 847
Total	2 071 651	10 889	2 354 276	13 095	2 691 937	12 847
Crushed stone, n.e.s.						
United States	66 788	1 646	48 683	1 473	65 868	2 382
Italy	43	6	71	8	155	24
Other countries	195	38	36	5	243	49
Total	67 026	1 690	48 790	1 486	66 266	2 455

Source: Statistics Canada.
- Nil; n.e.s. Not elsewhere specified.
Totals may not add due to rounding.

TABLE 4A. CANADA, EXPORTS AND IMPORTS OF SAND AND GRAVEL AND CRUSHED STONE, 1988P

Item No.		1988P Jan.-Sept. (tonnes)	1988P Jan.-Sept. ($000)
Exports			
2505.90	Natural sands n.e.s., excluding metal bearing sands		
	United States	208 993	1 518
	Other countries	38	13
	Total	209 031	1 531
2517.10	Pebbles, gravel broken or crushed stone used for aggregates, etc.		
	United States	1 358 359	8 682
	Bahamas	56 504	644
	Bermuda	20 695	167
	Other countries	17 062	95
	Total	1 452 620	9 588
2521.00	Limestone flux; limestone and other calcareous stone used for lime or cement		
	United States	794 680	4 719
	Other countries	169	83
	Total	794 849	4 802
Imports			
2505.90	Natural sands n.e.s., excluding metal bearing sands		
	United States	353 164	4 126
	Other countries	96	7
	Total	353 260	4 133
2517.10	Pebbles, gravel broken or crushed stone used for aggregates, etc.		
	United States	463 671	2 844
	Total	463 671	2 844
2521.00	Limestone flux; limestone and other calcareous stone for lime or cement		
	United States	1 841 167	6 629
	Total	1 841 167	6 629

Source: Statistics Canada.
n.e.s. Not elsewhere specified; P Preliminary.

TABLE 5. LIGHTWEIGHT AGGREGATE PLANTS IN CANADA, 1987

Company	Location	Commodity	Remarks
Atlantic Provinces			
Annapolis Valley Peat Moss Company Limited	Berwick, N.S.	Vermiculite	Processed mainly for use in horticulture.
Avon Aggregates Ltd.	Minto, N.B.	Expanded Shale	Processed for concrete products industry.
Quebec			
Armstrong World Industries Canada Ltd.	Gatineau	Perlite	Processed for use in ceiling tile manufacture.
Domtar Inc.	Montreal	Perlite, Vermiculite	Processed material purchased for use in gypsum plaster and wallboard at all company plants.
Perlite Industries Inc.	Ville Saint-Pierre	Perlite	Processed for use in horticulture and as industrial filler.
Ontario			
CGC Inc.	Hagersville	Perlite	Processed for use in gypsum plaster.
National Slag Limited	Hamilton	Slag	Used in concrete blocks and as slag cement.
W.R. Grace & Co. of Canada Ltd.	St. Thomas	Vermiculite	Vermiculite processed for use in horticulture and as loose insulation.
	Ajax	Vermiculite, Perlite	Perlite processed for use in gypsum plaster, in horticulture, refractories, as loose insulation, in friction materials and in fireproofing.
Prairie Provinces			
Apex Aggregate	Saskatoon, Sask.	Expanded clay	Processed for concrete block manufacture.
Cindercrete Products Limited	Regina, Sask.	Expanded clay	Processed for concrete products industry.
Consolidated Concrete Limited	Calgary, Alta.	Expanded shale	Processed for concrete products industry.
	St. Albert, Alta.	Expanded clay	Processed for concrete products industry.
CBR Cement Canada Limited	Edmonton, Alta.	Expanded shale	Processed for concrete block manufacture.
Kildonan Concrete Products Ltd.	Winnipeg, Man.	Expanded clay	Processed for concrete products industry.
W.R. Grace & Co. of Canada Ltd.	Winnipeg, Man.	Vermiculite, Perlite	Perlite processed for use in gypsum plaster and in horticulture.
	Edmonton, Alta.	Vermiculite, Perlite	Vermiculite processed for use in horticulture and as loose insulation.
British Columbia			
Ocean Construction Supplies Limited	Vancouver	Pumice	Purchased for concrete block manufacture.
Aurun Mines Ltd.	Surrey	Perlite	Integrated mine, process and marketing.

TABLE 6. CANADA, IMPORTS OF VERMICULITE, PERLITE AND PUMICE, 1986 AND 1987

	1986		1987	
	(tonnes)	($000)	(tonnes)	($000)
Vermiculite, crude				
United States	20 859	3 744	17 125	2 919
South Africa	3 340	527	8 135	1 284
Total	24 199	4 271	25 260	4 203
Perlite, excluding expanded				
United States	-	1 799	-	1 574
Mexico	-	-	-	5
Total	-	1 799	-	1 579
Pumice, lava and volcanic dust, crude/ground				
United States	20 618	1 737	19 715	4 208
Iceland	422	336	423	362
Italy	1 573	87	253	159
Other countries	118	50	1 073	249
Total	22 731	2 210	21 464	4 978
Vermiculite, expanded				
United States	-	14	-	17
Perlite, expanded				
United States	-	905	-	989
Italy	-	5	-	-
Taiwan	-	5	-	-
Total	-	915	-	989

Source: Statistics Canada.
- Nil.

TABLE 6A. CANADA, IMPORTS OF VERMICULITE, PERLITE AND PUMICE, 1988P

Item No.		1988P Jan.-Sept.	
		(tonnes)	($000)
2513.11	Pumice stone: crude or in irregular pieces, including crushed pumice		
	United States	2 476	1 147
	Italy	152	40
	Other countries	89	42
	Total	2 717	1 229
2513.19	Pumice stone: other		
	United States	2 261	983
	Italy	403	162
	Iceland	305	147
	Other countries	333	135
	Total	3 302	1 427
2530.10.10.10	Vermiculite, unexpanded		
	United States	11 245	2 074
	South Africa	5 115	753
	Total	16 360	2 827
2530.10.10.20	Perlite, unexpanded		
	United States	11 159	1 256
	Greece	574	43
	Mexico	154	22
	Total	11 887	1 321
3802.90.20.	Activated perlite, excluding expanded perlite ground to be employed in filtering		
	United States	1 358	660
6806.20.00.10	Exfoliated (expanded) vermiculite		
	United States	149	173
6806.20.00.20	Expanded perlite		
	United States	793	574

Source: Statistics Canada.
P Preliminary.

TABLE 7. CANADA, SALES OF LIGHTWEIGHT AGGREGATES, 1986 AND 1987

	1986		1987	
	(m^3)	($)	(m^3)	($)
From domestic and/or imported raw materials				
Expanded clay, shale and slag	246 415	7 060 480	368 812	8 896 827
From imported crude materials				
Expanded perlite and exfoliated vermiculite[1]	322 460	12 806 998	320 759	13 460 225
Total	568 875	19 867 478	689 571	22 357 052

Source: Company data. See Table 5 for list of establishments surveyed.
[1] Combined to avoid disclosing confidential company data.

TABLE 8. CANADA, SALES OF SLAG, PERCENTAGE BY END-USE, 1985-87

Use	1985	1986	1987
Concrete block manufacture	28.0	29.0	38.3
Ready-mix concrete	1.0	3.0	3.8
Loose insulation	1.0	1.0	-
Slag cement	70.0	67.0	55.4
Precast concrete manufacture	-	-	2.5

Source: Company data. See Table 5 for list of establishments surveyed.
- Nil.

TABLE 9. CANADA, SALES OF EXPANDED CLAY AND SHALE, PERCENTAGE BY END-USE, 1985-87

Use	1985	1986	1987
Concrete block manufacture	78.2	79.8	80.1
Precast concrete manufacture	5.1	6.7	5.4
Ready-mix concrete	12.0	7.3	5.5
Horticulture and miscellaneous uses	4.7	6.2	9.0

Source: Company data. See Table 5 for list of establishments surveyed.

TABLE 10. CANADA, SALES OF EXPANDED PERLITE, PERCENTAGE BY END-USE, 1985-87

Use	1985	1986	1987
Insulation			
in gypsum products	31.6	14.4	9.3
in other construction materials	37.7	33.3	43.2
Horticulture and agriculture	25.7	36.6	34.2
Loose insulation and miscellaneous uses	5.0	15.7	13.4

Source: Company data. See Table 5 for list of establishments surveyed.

TABLE 11. CANADA, SALES OF EXFOLIATED VERMICULITE, PERCENTAGE BY END-USE, 1985-87

Use	1985	1986	1987
Insulation			
loose	23.9	21.6	12.6
in concrete and concrete products	-	-	-
in gypsum products	-	-	-
Horticulture	64.3	53.5	48.7
Miscellaneous uses	11.8	24.9	38.7

Source: Company data. See Table 5 for list of establishments surveyed.
- Nil.

TABLE 12. CANADA, VALUE OF CONSTRUCTION[1] BY TYPE, 1986-88

	1986	1987	1988
		($ millions)	
Building Construction			
Residential	28 885	36 003	35 651
Industrial	3 201	3 189	3 339
Commercial	10 119	12 068	13 097
Institutional	3 565	4 172	4 202
Other building	1 656	1 796	1 987
Total	47 427	57 228	58 277
Engineering Construction			
Marine	335	361	489
Highways, airport runways	5 192	5 065	5 284
Waterworks, sewage systems	2 377	2 294	2 553
Dams, irrigation	243	248	287
Electric power	3 370	3 625	4 443
Railway, telephones	2 753	2 954	3 024
Gas and oil facilities	6 728	5 917	7 490
Other engineering	3 275	3 164	3 432
Total	24 274	23 628	27 002
Total construction	71 701	80 856	85 279

Source: Statistics Canada.

[1] Actual expenditures 1986, preliminary actual 1987, intentions 1988.

TABLE 13. CANADA, VALUE OF CONSTRUCTION[1] BY PROVINCE, 1986-88

	1986			1987			1988		
	Building Construction	Engineering Construction	Total	Building Construction	Engineering Construction	Total	Building Construction	Engineering Construction	Total
	($000)								
Newfoundland	802 442	809 153	1 611 595	878 732	696 895	1 575 627	898 710	664 234	1 562 944
Nova Scotia	1 493 407	872 077	2 365 484	1 694 516	715 721	2 410 237	1 752 532	785 781	2 538 313
New Brunswick	1 042 640	428 756	1 471 396	1 178 179	465 024	1 643 203	1 229 301	470 882	1 700 183
Prince Edward Island	223 287	70 364	293 651	222 907	72 148	295 055	241 763	86 388	328 151
Quebec	11 690 251	3 888 916	15 579 167	13 971 089	4 158 213	18 129 302	13 799 399	4 888 767	18 688 166
Ontario	19 480 274	5 824 510	25 304 784	24 148 448	6 061 990	30 210 438	24 509 690	6 807 027	31 316 717
Manitoba	1 870 090	928 101	2 798 191	1 992 684	942 052	2 934 736	2 033 533	1 154 802	3 188 335
Saskatchewan	1 563 702	1 396 406	2 960 108	1 808 053	1 502 338	3 310 391	1 792 538	1 732 571	3 525 109
Alberta	4 109 233	6 239 982	10 349 215	4 775 800	5 663 670	10 439 470	4 892 445	7 048 038	11 940 483
British Columbia, Yukon and Northwest Territories	5 151 540	3 815 498	8 967 038	6 557 677	3 349 923	9 907 600	7 126 702	3 363 932	10 490 634
Canada	47 426 866	24 273 763	71 700 629	57 228 085	23 627 974	80 856 059	58 276 613	27 002 422	85 279 035

Source: Statistics Canada.

[1] Actual expenditures 1986, preliminary actual 1987, intentions 1988.

Nickel

R.G. TELEWIAK

The nickel market was extremely tight in 1988 due to a combination of record high demand, low inventories and some supply disruptions. The result was unprecedently high nickel prices.

Demand in the western world increased by an estimated 2% in 1988 over the 1987 level, to about 655 000 t. Demand was particularly strong from the stainless steel sector, which accounts for about 55% of nickel consumption.

Inventories were low at the start of the year and despite the producers operating at their effective capacities for most of the year, inventories were drawn down to very low levels by year-end. Some supply disruptions at a few operations in various parts of the world added to the market tightness.

The nickel spot price on the London Metal Exchange (LME) averaged US$6.25/lb. in 1988 compared to US$2.21 in 1987. A record high of $10.84 was reached on March 28.

SUPPLY - CANADIAN DEVELOPMENTS

Canadian nickel production increased in 1988 due mainly to higher production by INCO Limited at Thompson, Manitoba. Production of Falconbridge Limited, the other domestic integrated producer, was little changed from last year. (Additional information on nickel mines is listed in the table on Nonferrous Metal Mines which follows the last commodity chapter of this Yearbook.)

INCO and Falconbridge reached new three-year contracts during the summer with their unions at Sudbury and for INCO also at Port Colborne, Ontario. A 13-day strike occurred at Falconbridge's Sudbury operations before a settlement was reached and 1 400 t of nickel production was lost. Both contracts included an immediate cash increase and a quarterly bonus tied to the companies' realized nickel prices.

Both companies had major corporate developments. INCO implemented a recapitalization program which included a special $1.2 billion dividend to shareholders and a shareholders rights plan to discourage an unfriendly takeover of the company. For Falconbridge, Noranda Inc. acquired a 19.6% interest to become the largest shareholder.

At Thompson, Manitoba, INCO announced that it would proceed with the $100 million mine development of the Thompson Open Pit South and the reactivation of the Birchtree. The mines will replace the Thompson Open Pit North which is expected to be mined out in 1990.

The new open pit is expected to be in production for five years and the Birchtree for more than 20 years. The Birchtree had operated from 1966 to 1977 and it is expected productivity will be twice as high after it reopens compared to when it last operated. The $58 million being spent to reactivate the mine will include deepening the shaft from 1027 m to 1338 m, driving additional drifts and the installation of new equipment. Bulk mining methods will be incorporated.

Falconbridge announced a $33 million underground program at its Lindsley property, near Sudbury. A shaft will be sunk to 1390 m followed by a drifting and drilling program on the 1310 m level. Several potentially mineable ore zones have been identified. The program will be completed in 1991.

Sherritt Gordon Limited produced about 24 000 t of nickel in briquettes and powder at its Fort Saskatchewan, Alberta refinery. The major source of feed was INCO, with concentrates obtained from Thompson and matte from Sudbury. The 10-year contract between Sherritt Gordon and INCO expires at the end of 1989 and will not be renewed. Sherritt Gordon has an agreement with Hudson Bay Mining and Smelting Co., Limited (HBMS) to refine the latter's 60% share of the concentrate to be produced at

---

R.G. Telewiak is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 992-4481.

Namew Lake and some additional possible sources of feed are also being pursued.

The Namew Lake nickel mine, owned 60% by Hudson Bay and 40% by Outokumpu Mines Ltd., was commissioned on November 15. The $70 million project is expected to produce 9 200 t/y of nickel in concentrate and 3 500 t/y of copper in concentrate, once full production is achieved. Some excess water has been encountered underground but full production could occur in the second quarter of 1989. Reserves are 2.6 Mt grading 2.44% nickel and 0.9% copper and are sufficient for 5½ years of operation. Breakeven costs are US$1.60/lb. nickel. Outokumpu has a contract with INCO to process its 40% share of the output.

With nickel prices at record levels, there was renewed interest in the nickel deposit of New Quebec Raglan Mines Limited in the Ungava region of northern Quebec but little additional exploration. Reserves are indicated to be 10.9 Mt grading 3.11% nickel and 0.8% copper with some values in platinum group metals. The company, which is controlled by Falconbridge, has indicated that sustained prices of US$4/lb., in 1988 dollars, would be needed to bring the deposit into production.

Late in the year, INCO announced that there would be normal summer shutdowns at its operations in 1989. The Sudbury operations would be closed from July 3 to August 8 and the Port Colborne refinery will close for five weeks in July and August. At Thompson, the Thompson and Birchtree mines will close from July 3 to July 30 and the Thompson Open Pit from August 7 to September 4, but the surface facilities will operate throughout the summer at a reduced rate.

The question of domestic resource adequacy has been raised for certain metals but, compared to some others, there is little concern about the ability of the domestic resource base to sustain current levels of nickel production for many years. While nickel reserves have been dropping for the past few years, outlined reserves are still sufficient to sustain forecasted production levels, for more than 20 years. As well, there are excellent prospects to increase reserves at both Sudbury and Thompson.

SUPPLY - WORLD DEVELOPMENTS

Nickel producers generally operated at their effective capacities to take advantage of the high prices but various producers experienced some strikes or technical or other difficulties which reduced their production from planned levels. Some mines which were shut down during the depressed market conditions of the mid-1980s were re-examined and consideration was given for possible expansions of existing operations.

In the Dominican Republic, production of 5 300 t nickel contained in ferronickel was lost as a result of the closure of Falconbridge Dominicana, C. por A. (Falcondo) from mid-April until mid-June. The operations had been closed by the company until an agreement was reached with the government on a new tax system. Exports had been intermittent in the first part of the year.

In Brazil, strikes shut down the 5 000 t/y electrolytic nickel complex of Companhia Niquel Tocantins and the 8 000 t/y ferronickel operations of Corporacion de Desarrollo Minero Cerro Colorado (Codemin) from November 11 to December 22. The disputes were over wages.

In Australia, production of about 1 300 t of nickel in concentrate was lost by Western Mining Corporation Limited at Kambalda due to a 12-day strike in March. Late in the year, production of Western Mining was also affected by technical difficulties at the Kambalda smelter. Its refinery at Kwinana was also closed starting in late December for a four-week maintenance program.

Western Mining purchased the Agnew nickel mine in Western Australia from BP Minerals Limited and M.I.M. Holdings Limited. The mine was closed in 1986 in response to prevailing weak nickel markets and Western Mining announced late in the year that the mine would be reopened in the first half of 1989. The operation had previously produced about 10 000 t/y of nickel in concentrate and it is expected that it would take at least one year to bring the operation up to full capacity. Overburden removal will commence in January in preparation for open pit mining at the nearby Rocky Reward deposit.

Queensland Nickel Pty Ltd., which operates the Greenvale complex, proceeded with a $100 million development project primarily for construction of new docking and unloading facilities to handle additional imported laterite ore for its processing at Yabula near Townsville. About 1 Mt of ore was imported from New Caledonia and Indonesia in 1988 and this could be doubled in 1989. Some modifications to the plant are also planned which could increase capacity by 20% to 35 000 t/y of nickel.

In Indonesia, production of P.T. International Nickel Indonesia was lower than planned due to problems with the electric power generation facility early in the year and a blowout of the transformer on the number two furnace in December. About 28 100 t of contained nickel in matte was produced compared to the planned output for the year of 34 900 t. In 1987, the company produced 26 300 t.

Sumitomo Metal Mining Co. Ltd. acquired a 20% equity interest in P.T. International Nickel from INCO. As part of the arrangement, Sumitomo will purchase about 20% of the output from the operation which will also be expanded from 36 300 t to 47 600 t/y, over the next two years.

China, in an effort to reduce nickel exports, put a 40% export tariff on nickel at the beginning of the year. Demand for nickel in China has been growing rapidly in recent years and China consumed more nickel in 1988 than it produced. Late in the year, the government announced that effective January 1, 1989, the export of nickel, nickel alloys and nickel products would be banned.

An expansion was started at the Jinchuan nickel complex in the Gansu province of western China to double the capacity to 40 000 t/y of nickel metal. Outokumpu flash furnaces are being installed. The expansion is planned to be completed in 1990.

Nonoc Mining & Industrial Corporation did not operate its Suriago nickel complex during the year but plans were announced to sell the company on January 12, 1989. Interested parties were reported to include the Bond Corporation Holdings Limited of Australia and the Soviet Union. The complex was closed in late 1986 due to weak nickel markets. Capacity is 30 800 t/y of refined nickel plus 3 000 t of nickel and 1 500 t of cobalt in mixed nickel-cobalt sulphides.

The ferronickel complex of Hellenic Mining and Metallurgical Company of Larymna S.A. (LARCO) in Greece was auctioned off in December to the Greek government's Organization for the Rehabilitation of Enterprises. Plans to convert part of the plant's capacity to ferrochrome production were put on hold pending the appointment of new managers. Production in 1989 is planned to be 14 000 t/y of nickel contained in ferronickel compared to about 12 500 t in 1988.

In Cuba, technical problems on the first 10 000 t/y furnace line of the Punta Gorda plant were largely resolved and the line was expected to have been producing at capacity. When completed, perhaps over the next two to three years, the plant will have a capacity of 30 000 t/y of nickel.

In Norway, Falconbridge started in the second half of the year to process nickel-copper matte from Norilsk. A contract was signed with a Yugoslavian firm for 20 000 t/y of matte over a three-year period. The Yugoslavians had acquired the matte in a countertrade deal involving the construction of a hospital in Norilsk. The matte is close to 40% nickel, 35% copper plus cobalt, platinum group metals and some other minor metals.

Net exports from the centrally-planned countries to the western world were estimated to have changed little from the previous year. While estimates vary, it is believed that exports were about 65 000 t. An increase in Cuban and Soviet exports were offset by increased purchases by China.

A Canadian government/industry nickel delegation visited the Soviet Union in September and toured the Severonickel complex in the Kola Peninsula and the Yuzhuralnikel complex in the southern Urals, and held discussions with ministries in Moscow. The delegation left convinced that Soviet nickel production was substantially higher than previously estimated. While refined production had been estimated at about 190 000 t/y it is now believed that production is closer to 350 000 t/y .

CONSUMPTION AND USES

Nickel consumption was strong in 1988 in all major market areas, particularly in the capital goods sector which generally accounts for about two-thirds of consumption. The manufacturing sector continued to modernize and add some capacity and this increased the demand for various nickel containing products.

While strong demand from the consumer goods sector had led the increase in nickel consumption over the past few years, in 1988 the capital goods sector became much more important.

In the United States, the operating rate at factories, mines and utilities rose to the highest level in nine years. The use of industrial capacity, according to the Federal Reserve Board, rose to 84.2% in November. Similarly, the operating rate was high in Japan and western Europe.

Nickel containing stainless steels continue to be the major growth market for nickel. The demand for nickel to be used in these steels has been increasing faster than for other nickel containing products. The percentage of total nickel consumption accounted for by this sector is currently about 55%. It is expected that this percentage will continue to increase for several years to come.

The major nickel markets of the United States, Japan and western Europe continue to account for close to 90% of the demand for nickel in the western world but the newly industrialized countries, particularly in the Pacific Rim region, are increasing their share of the market and this is expected to continue in the future.

Resistance to corrosion, high strength over a wide temperature range, pleasing appearance and suitability as an alloying agent are characteristics of nickel which make it useful in a wide range of applications. After stainless steels the major uses are nickel-based alloys, electroplating, alloy steels, foundry products and copper-based alloys. Nickel is extensively used as an alloying agent and is a component in some 3000 different alloys which are used in more than 250 000 end-use applications.

Nickel is used in chemical and food processing, nuclear power plants, aerospace equipment, motor vehicles, oil and gas pipelines, electrical equipment, machinery, batteries, catalysts, and many other applications.

Nickel containing stainless steel tanks are used for road, rail and sea transport of various liquids including dairy products, petrochemicals and toxic chemicals. Nickel containing stainless steels are used for their resistance to corrosion, strength and ease of cleaning. The ability to handle a wide variety of liquids adds to its capability for backhaul loads.

In recent years, some Japanese and European auto manufactures have been using a zinc-nickel coated steel for various body panels and some structural parts. The coating is much more corrosion resistant than ordinary galvanized steel. Bethlehem Steel Corporation acquired the licence from Nippon Kokan KK (NKK) of Japan in 1988 for the manufacture in the United States of the coating which contains about 13% nickel with the remainder zinc. Commercial production of the coating is expected in the second quarter of 1989 from a plant in Walbridge, Ohio. This market for nickel, although relatively small, is expected to grow in the future. As well, the enhanced appearance and low weight of this product makes it potentially attractive for certain other uses.

Specialty nickel powders are produced by some companies which have applications in various relatively small but important markets including rechargeable batteries, powder metallurgy alloys, electromagnetic shielding, electronic components, special paints and pigments, and automotive catalysts.

MARKETS AND PRICES

Nickel prices at the end of 1987 had been at record highs due to tight markets which were exacerbated by the cessation of nickel exports by Falconbridge Dominicana. A spot price of US$4.24/lb. was reached on the LME on December 30.

Prices retreated somewhat in early 1988 and the January price averaged US$3.67. The continued curtailment of exports from the Dominican Republic combined with some other relatively minor supply disruptions, and slightly higher demand, resulted in prices rising precipitously in March. Inventories were also low. Stocks on the LME fell to 1 800 t in late March compared to 4 600 t in early January.

Prices retreated from this unrealistically high level, with the second quarter averaging $7.76. The Dominican dispute was resolved in May and this added to available supplies, partially due to the release of 6 000 t of stockpiled material.

Producers continued to operate at their effective capacities but were unable to build inventories due to continuing strong demand, particularly from the stainless steel sector. In the past few years, producers had closed some plants and foregone expansion plans in response to weak prevailing markets and, as a result, production could not be expanded quickly or substantively to take advantage of strong market conditions.

Prices generally retreated in the third quarter with a temporary increase in August due to the strike at Falconbridge, Sudbury. The average for the quarter was $6.18.

In the fourth quarter, prices generally increased in response to the tight market conditions. Supply disruptions due to the strikes in Brazil and the transformer blowout at P.T. International Nickel, added to the tightness. LME stocks were 2 540 t at the end of the year. Prices averaged $6.32/lb. for the quarter.

INTERNATIONAL NICKEL STUDY GROUP

At the United Nations Conference on Nickel, which concluded on May 2, 1986, negotiations took place involving over thirty nickel producing and consuming countries, on the Terms of Reference for the International Nickel Study Group (INSG). It was agreed that the INSG would be an autonomous intergovernmental organization which would collect and publish statistical information on the international nickel economy and provide a forum for discussion of issues of concern to the industry.

The Secretary General of the United Nations forwarded copies of the Terms of Reference to all governments invited to the Conference, and urged governments to notify the United Nations of their acceptance of them before September 20, 1986.

Five countries provided notification before the deadline: Federal Republic of Germany, Finland, Netherlands, Sweden and Canada. France, Greece, Australia and Norway subsequently joined. The U.S.S.R. has notified the United Nations of its intent to join. Cuba has stated that it will join at the inaugural meeting. Together these eleven countries account for about 51% of world trade in nickel.

Several other countries have indicated an intent to join, or a strong interest in the INSG, including Italy, Zimbabwe, Spain, Brazil, China, Indonesia, Colombia, Republic of Korea, Japan and the United States. The Specialty Steel Industry of the United States has been urging the U.S. government to join.

An inaugural meeting of the INSG will be held after 15 countries join which account for 50% or more of trade in nickel, but can also be held if the current member countries decide to proceed with less than the 15 country target. If this latter option is followed it would be in the expectation that additional countries will join once the organization is established.

The headquarters of the INSG is expected to be in the Hague, Netherlands.

HEALTH AND ENVIRONMENT

Under a 1985 Ontario government regulation, INCO and Falconbridge must reduce their emissions of sulphur dioxide to 265 000 t and 100 000 t, respectively. In 1985, the limit was 685 000 t for INCO and 154 000 t for Falconbridge.

Inco announced a $494 million program which would put the company in compliance with the regulation. Of the total, $425 million will be for changes to the smelter. The program includes two oxygen flash furnaces, a new sulphuric acid plant, an additional oxygen plant plus some other plant modifications. The new furnaces, which INCO has developed, will utilize pure oxygen as the fuel and will replace the existing two reverberatory furnaces.

The remaining $69 million will be spent on a mill modernization and rationalization program at Sudbury. The Clarabelle mill will be expanded to handle all the Sudbury ores. A bulk nickel-copper concentrate will be produced which will facilitate increased rejection of pyrrhotite. A semi-autogenous grinding circuit and large flotation cells will be installed. The Frood-Stobie mill will be closed and the Copper Cliff mill will be used only for concentrate dewatering and storage. As well as contributing to cleaning up the environment, the operating efficiency of the plant also will be substantially increased.

Falconbridge plans to spend $38 million on research, development and capital projects related to increasing pyrrhotite rejection and greater roasting, to be able to conform to the regulation. While actual emissions of sulphur dioxide in 1988 were below the required 1994 level, the company was producing below capacity. The company is conducting research on methods to reduce emissions to 75 000 t/y, at capacity production, by 1998. Increased pyrrhotite rejection is the focus of the research.

An issue of increasing concern to the nickel industry is the institution by various countries of stiffer regulations on exposure to nickel, some of which are unduly restrictive or overly broad in scope. Unnecessary expense can result for nickel producers and consumers and, as well, certain markets can be adversely affected.

In June 1989 the International Agency for Research on Cancer, which is the internationally recognized authority on human carcinogens, will be holding a special Working Group to examine in detail nickel and nickel compounds and some other metals. It is expected that this meeting will clear up some of the confusion surrounding the relationship between nickel and its compounds and cancer. The results should provide additional guidance to regulatory agencies around the world.

OUTLOOK

In 1989, it is expected that nickel demand will be slightly higher than in 1988, providing the economies of the major economies in the western world continue to grow as forecast. There is no indication of demand softening.

Producers are expected to continue to operate at their effective capacities and some additional production, including that from the reactivation of Agnew, is also anticipated. Barring any important supply disruptions, supplies could be about 3-4% higher than in 1988. Markets are expected to remain tight and this should keep prices firm.

Although prices at the end of 1988 are unsustainable in the medium to long term, if demand continues to increase significantly prices will remain high, perhaps in the US$6-8 range on the LME. Producers have little flexibility in the short term to increase production and inventories are very low. Prices could be quite volatile, given the tight market, if either demand or supply conditions change significantly.

Current high prices are encouraging the re-evaluation of shutdown capacity, the potential to expand existing operations and the possibilities of new greenfield operations. Much new capacity would be economic at current prices but decisions will likely be based on the expectation that future prices will be significantly lower.

The high prices prevailing for most of 1988, if sustained for long, will encourage substitution. While it takes time for current users of nickel to switch to substitute materials, such as plastics, ceramics and some other metals, this would occur. Once substitution takes place, it is difficult to recapture markets.

In the medium to longer term, prices in constant dollars will decline from the average LME price of US$7.69 in December 1988. While many factors will influence the actual price, it is felt that a price between US$3.75-$4.75 in constant 1988 dollars would assure adequate new supply.

Consumption is expected to grow at an annual rate of about 1.7% to the year 2000. While some more mature markets, like the United States and Japan, are expected to experience somewhat lower growth rates, this will be offset by higher rates in relatively small but emerging markets such as China, Brazil and South Korea.

In Canada, nickel production is expected to increase marginally over the next several years. Canada will remain a highly cost-competitive producer, particularly given the effects of the cost reduction programs which have been put in place in the past few years. An increasing amount of ore will be mined by low-cost bulk mining methods and this will be a significant factor in lowering costs, given that mining accounts for about 50% of current operating costs. A major constraint on production, particularly at INCO, Sudbury, will be the limit on permissible sulphur dioxide emissions from the smelter.

The most important potential new development in Canada over the next decade, could be the New Quebec Raglan Mines Limited property in northern Quebec. Although the remote location makes it expensive to develop and operate, the high grade deposits which could be mined by open pit methods makes it an attractive possibility.

TARIFFS

Item No.	Description	Canada			United States	EEC	Japan[1]
		MFN	GPT	USA[1]	Canada	MFN	MFN
2604.00	Nickel ores and concentrates	Free	Free	Free	Free	Free	Free
7501.10	-Nickel mattes	Free	Free	Free	Free	Free	Free
7501.20	-Nickel oxide sinters and other intermediate products of nickel metallurgy	Free	Free	Free	Free	Free	Free - 81 yen/kg[2]
75.02	Unwrought nickel						
7502.10	-Nickel not alloyed	Free	Free	Free	Free	Free	81 yen/kg
7502.20	-Nickel alloyed	Free	Free	Free	Free	Free	Free - 9%[3]
7503.00	Nickel waste and scrap	Free	Free	Free	Free	Free	Free
7504.00	Nickel powders and flakes						
7504.00.10	---Powders containing by weight 60% or more nickel	Free	Free	Free	Free	0.5%	Free - 65 yen/kg
7504.00.20	---Powders containing by weight less than 60% of nickel	10.2%	6.5%	8.1%	Free	0.5%	6%

Sources: Customs Tariffs, effective January 1989, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States (First Edition Supplement 2) effective January 1, 1989; Official Journal of the European Communities, Vol. 30, No. L256, 1987, "Conventional" column; Custom Tariff Schedules of Japan, 1988.

[1] GATT rate is shown, lower tariff rates may apply circumstantially. [2] Free except for nickel oxide sinters containing by weight not less than 88% of nickel which is 81 yen/kg, and nickel oxide containing by weight not more than 1.5% of copper which is 7.2%. [3] Tariff rate of 9% applies to nickel alloys other than those containing by weight less than 50% of nickel and not less than 10% of cobalt which is free.

TABLE 1A. CANADA, NICKEL PRODUCTION, TRADE AND CONSUMPTION, 1985-87

	1985		1986		1987	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Production[1]						
All forms						
Ontario	131 035	930 760	121 851	731 440	130 171	869 315
Manitoba	38 936	286 628	41 788	247 660	58 915	403 727
Total	169 971	1 217 388	163 639	979 100	189 086	1 273 043
Exports						
Nickel in ores, concentrates and matte						
United Kingdom	29 895	212 198^{r}	28 447	202 089	25 760	182 655
Norway	33 337	216 096^{r}	29 332	162 920	30 798	150 595
Belgium-Luxembourg	12	96	-	-	-	-
United States	61	427	1	4	-	-
Total	63 305	428 818^{r}	57 780	365 013	56 558	333 250
Nickel in oxides						
United States	..	54 748	..	38 442	..	75 552
United Kingdom	..	2 433	..	29 384	..	32 456
Belgium-Luxembourg	..	9 258	..	1 618	..	17 653
Japan	..	6 097	..	6 916	..	13 298
Finland	..	38 713	..	2 064	..	7 400
Germany, West	..	552	..	4 602	-	-
Other Countries	..	13 607^{r}	..	458^{r}	-	-
Total	17 971^{r}	125 408^{r}	13 917^{r}	83 484	20 715	146 359
Nickel and nickel alloy scrap						
United States	2 577	12 428	3 998	17 540	4 573	20 926
Netherlands	1 286	7 916	1 091	4 283	838	3 972
Finland	-	-	-	-	1 081	1 804
Other countries	963^{r}	5 418^{r}	969^{r}	1 911^{r}	1 135	4 062
Total	4 826	25 762	6 058	23 734	7 627	30 765
Nickel anodes, cathodes, ingots, rods						
United States	..	279 473	..	289 208	..	314 120
Belgium-Luxembourg	..	77 406	..	82 571	..	107 431
Japan	..	34 234	..	18 988	..	55 821
United Kingdom	..	25 665	..	11 897	..	13 291
Germany, West	..	7 335	..	5 831	..	7 640
Other countries	..	71 731^{r}	..	69 394^{r}	..	51 082
Total	81 690	495 844	86 007^{r}	477 889	96 121	549 385

Nickel and nickel alloy fabricated material, n.e.s.						
United States	8 663	69 186	7 823	61 224	11 178	82 854
Japan	1 124	9 697	1 007	6 927	1 233	11 545
Netherlands	122	892	357	2 221	417	3 437
Belgium-Luxembourg	573	3 164	505	2 867	402	2 250
United Kingdom	417	2 509	401	2 186	412	2 217
Other countries	1 443r	12 553r	678r	5 176r	1 141	8 443
Total	12 342	98 001	10 771	80 602	14 783	110 746
Imports						
Nickel in ores, concentrates and scrap						
United States	15 486	24 181	14 748	18 327	10 063	15 117
Australia	6 250	32 332	10 219	44 115	4 124	14 407
United Kingdom	6 567	7 733	9 642	13 069	6 500	8 086
Norway	97	461	2 348	2 136	2 244	1 851
Germany, West	-	-	-	-	188	367
Other countries	3 194r	4 138r	1 373r	2 043r	417	477
Total	31 594	68 845	38 330	79 690	23 536	40 304
Nickel anodes, cathodes, ingots, rods						
Norway	1 788	13 143	1 737	11 651	1 529	10 703
United States	917	6 974	1 106	7 273	720	4 290
United Kingdom	17	173	40	258	25	145
Germany, West	37	305	38	364	12	91
Other countries	5r	8r	40r	249r	-	-
Total	2 764	20 603	2 961	19 796	2 586	15 229
Nickel alloy ingots, blocks, rods and wire bars						
United States	391	4 665	424	5 648	634	6 721
West Germany	184	1 363	66	599	77	557
Other	1	11	-	-	54	207
Total	576	6 039	490	6 247	765	7 485
Nickel and alloy plates, sheet, strip						
United States	603	9 812	578	8 411	799	9 640
Germany, West	658	4 159	687r	4 713r	743	5 170
Sweden	17	93	30	301	60	379
United Kingdom	3	66	1	4	5	203
Other countries	26r	191r	23r	236r	3	30
Total	1 307	14 321	1 319r	13 665r	1 610	15 421

TABLE 1A. (cont'd)

	1985		1986		1987	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Nickel and nickel alloy pipe and tubing						
United States	128	2 187	126	2 474	210	3 415
United Kingdom	58	824	187	2 105	220	1 933
Germany, West	67	783	45	557	45	750
Sweden	233	2 331	70	1 312	9	49
Other countries	37r	636r	53r	935r	1	15
Total	523	6 760	481	7 384	485	6 163
Nickel and alloy fabricated material, n.e.s.						
United States	627	19 203	537	19 602r	691	21 538
Germany, West	155	1 998	106	1 159	83	963
United Kingdom	17	239	65	460	34	309
Sweden	2	21	2	23	24	178
Other countries	27r	355r	5r	77r	16	121
Total	828	21 816	715	21 320	848	23 108
Consumption[2]	7 206r	..	8 865r	..	9 738p	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Refined nickel and nickel in oxides and salts produced, plus recoverable nickel in matte and concentrates exported.

[2] Consumption of metallic nickel, all forms (refined metal and in ferronickel, oxides and salts) as reported by consumers on the EMR survey, "Consumption of Nickel".

r Revised; - Nil; .. Not available; n.e.s. Not elsewhere specified.

Note: Components may not add due to rounding.

TABLE 1B. CANADA, NICKEL PRODUCTION AND TRADE, 1988P

Item No.		1988P	
		(tonnes)	($000)
Production[1]			
All forms			
Ontario		142 292	2 166 259
Manitoba		71 579	1 089 714
Total		213 871	3 255 974
Exports[2]		(Jan.-Sept.)	
2604.00.40	Nickel ores and concentrates, nickel content		
	Norway	7 530	44 686
	United States	29	383
	West Germany	2	37
	Total	7 561	45 106
7501.00	Nickel mattes, nickel oxide sinters and other intermediate products of nickel metallurgy		
	Norway	17 797	162 351
	United Kingdom	21 282	150 836
	United States	60	269
	Total	39 139	313 456
7502.20	Nickel unwrought, alloyed		
	United States	1 425	11 241
	Belgium	333	2 415
	Other countries	282	2 039
	Total	2 040	15 695
7503.00	Nickel waste and scrap		
	United States	4 018	30 048
	Netherlands	417	2 780
	South Korea	256	1 840
	United Kingdom	282	718
	Other countries	651	1 321
	Total	5 624	36 707
7504.00	Nickel powders and flakes		
	United States	5 627	53 650
	Japan	1 037	8 988
	Netherlands	371	5 395
	South Korea	92	1 066
	People's Republic of China	102	942
	Other countries	582	4 185
	Total	7 811	74 226
7508.00	Articles of nickel, n.e.s.		
	United States	..	420 071
	Belgium	..	79 080
	Japan	..	59 328
	Taiwan	..	56 695
	Netherlands	..	32 581
	United Kingdom	..	30 933
	Singapore	..	14 808
	Other countries	..	26 569
	Total	..	720 065

TABLE 1B. (cont'd)

Item No.		1988P Jan.-Sept.	
		(tonnes)	($000)
Imports[3]			
2604.00.00.20	Nickel ores and concentrates, nickel content		
	United States	2 323	4 698
	Total	2 323	4 698
7501.00	Nickel mattes, nickel oxide sinters, and other intermediate products of nickel metallurgy		
	Australia	2 451	17 569
	United Kingdom	810	1 281
	Other countries	364	1 406
	Total	3 625	20 256
7502.10	Nickel unwrought, not alloyed		
	Norway	655	4 338
	United Kingdom	124	1 962
	United States	178	584
	Other countries	93	565
	Total	1 050	7 949
7502.20	Nickel unwrought, alloyed		
	United States	250	1 460
	Total	250	1 460
7503.00	Nickel waste and scrap		
	United States	9 245	21 530
	United Kingdom	826	1 318
	Australia	690	2 520
	Other countries	820	1 704
	Total	11 581	26 072
7504.00	Nickel powder and flakes		
	United States	96	1 165
	Other countries	34	388
	Total	130	1 553
7505.12	Bars, rods and profiles of nickel alloy		
	United States	367	7 448
	Other countries	19	316
	Total	386	7 764
7508.00.10.00	Nickel anodes for electro-plating		
	United States	119	1 021
	Other countries	40	351
	Total	159	1 372

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Refined nickel and nickel in oxides and salts produced, plus recoverable nickel in matte and concentrates exported. [2] Item No. 7502.10 nickel unwrought, not alloyed suppressed due to confidentiality. [3] Imports from "other countries" may include re-imports from Canada.
P Preliminary; .. Not available or not applicable; n.e.s. Not elsewhere specified.
Note: Components may not add due to rounding.

TABLE 2. CANADA, NICKEL PRODUCTION, TRADE AND CONSUMPTION, 1970, 1975 AND 1980-87

		Exports					
	Production[1]	In Matte etc.	In Oxide Sinter	Refined Metal	Total	Imports[2]	Consumption[3]
				(tonnes)			
1970	277 490	88 805	39 821	138 983	267 609	10 728	10 699
1975	242 180	84 391	38 527	91 164	214 082	12 847	11 308
1980	184 802	42 647	16 989	88 125	147 761	4 344	9 676
1981	160 247	53 841	14 390	79 935	148 166	2 335	8 603
1982	88 581	27 037	13 127	62 314	102 478	2 588	6 723
1983	125 022	40 087	11 167	66 949	118 203	2 357	5 010
1984	173 725	59 409	20 079	153 935	233 423	3 480	7 502[r]
1985	169 971	63 305	17 971	81 690	162 966[r]	2 764	7 206[r]
1986	163 640	57 780	13 917[r]	86 007[r]	157 704	2 961[r]	8 865[r]
1987	189 086	56 558	20 715	96 121	173 394	2 586	9 738[P]

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Refined nickel and nickel in oxide and salts produced, plus recoverable nickel in matte and concentrates exported. [2] Refined nickel, comprising anodes, cathodes, ingots, rods and shot. [3] Consumption of metallic nickel, all forms (refined metal, and in ferronickel oxides and salts) as reported by consumers on the EMR survey "Consumption of Nickel".
P Preliminary; [r] Revised.

TABLE 3. CANADIAN PROCESSING CAPACITY, 1988

	Inco			Falconbridge	Sherritt Gordon
	Port Colborne	Sudbury	Thompson	Sudbury	Fort Saskatchewan
			(tpy of contained nickel)		
Smelter	n.a.	110 000[1]	81 600	45 000	n.a.
Refinery	30 000	56 700	49 900	n.a.	24 000

[1] Capacity is constrained to this level by an Ontario government regulation on SO_2 emission limits.
n.a. Not applicable.

TABLE 4. WORLD MINE PRODUCTION OF NICKEL, 1986 AND 1987

	1986	1987
	(tonnes)	
Canada[1]	163 600	189 100
U.S.S.R.[2]	166 000	173 000
Australia	76 700	72 500
New Caledonia	64 500	58 700
Indonesia	67 300	57 200
Cuba	31 800	35 900
South Africa	35 100	34 300
Botswana	19 000	16 500
People's Republic of China	29 400	20 400
Dominican Republic	24 100	32 500
Other	95 400	83 800
Total	769 900	783 900

Sources: World Bureau of Metal Statistics (WBMS); Energy, Mines and Resources Canada.

[1] Refined nickel and nickel in oxide and salts produced, plus recoverable nickel in matte and concentrates produced. [2] As a result of the September 1988 Canadian government/industry nickel misssion to the U.S.S.R., it is believed that the data from the WBMS significantly understates Soviet production but an alterate number is not put forward at this time.

TABLE 5. WORLD CONSUMPTION OF NICKEL, 1986 AND 1987

	1986	1987
	(tonnes)	
Japan	126 600	153 900
United States	124 800	148 300
U.S.S.R.[1]	137 000	138 000
Germany, F.R.	77 300	81 100
France	31 900	39 300
Italy	29 500	28 800
United Kingdom	27 400	33 100
People's Republic of China	23 000	25 000
Sweden	17 100	16 800
India	16 000	19 300
Other	166 500	201 300
Total	777 100	884 900

Sources: World Bureau of Metal Statistics (WBMS); Energy, Mines and Resources Canada.

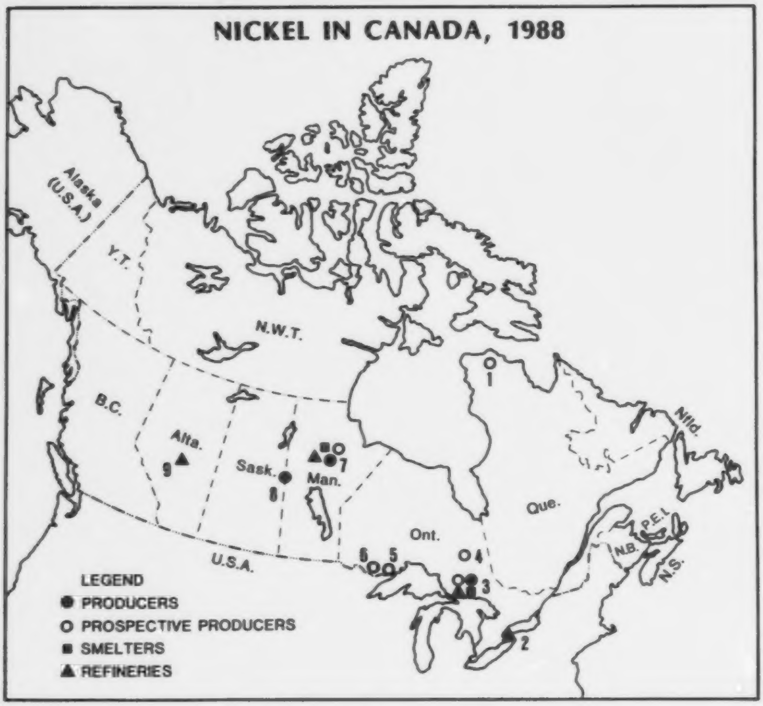
[1] As a result of the September 1988 Canadian government/industry nickel misssion to the U.S.S.R., it is believed that the data from the WBMS significantly understates Soviet consumption but an alterate number is not put forward at this time.

TABLE 6. ANNUAL NICKEL PRICES, 1980-88

Year	London Metal Exchange - Spot Current	 Constant
	(US$/lb.)	
1980	2.96	4.20
1981	2.71	3.50
1982	2.18	2.65
1983	2.12	2.48
1984	2.16	2.44
1985	2.22	2.43
1986	1.76	1.88
1987	2.19	2.26
1988	6.25	6.25

TABLE 7. AVERAGE MONTHLY NICKEL PRICES, 1987 AND 1988

	London Metal Exchange - Spot 1987	 1988
	(US$/lb.)	
January	1.60	3.67
February	1.69	3.94
March	1.71	7.09
April	1.76	8.21
May	2.02	7.75
June	2.02	7.10
July	2.16	6.63
August	2.40	6.48
September	2.42	5.43
October	2.58	5.27
November	2.70	6.07
December	3.48	7.69



NICKEL IN CANADA, 1988

Alaska (U.S.A.)
Y.T.
N.W.T.
B.C.
Alta.
Sask.
Man.
Ont.
Que.
Nfld.
P.E.I.
N.B.
N.S.
U.S.A.
1
2
3
4
5
6
7
8
9
LEGEND
● PRODUCERS
○ PROSPECTIVE PRODUCERS
■ SMELTERS
▲ REFINERIES

Producers, prospective producers, smelters and refineries
(numbers refer to locations on map above)

Producers

3. Falconbridge Limited
   (Craig, East, Falconbridge Open Pit, Fraser, Lockerby, Onaping, Strathcona)
   INCO Limited
   (Copper Cliff North, Copper Cliff South, Crean Hill, Creighton, Frood, Levack, Little Stobie, McCreedy West and Stobie)
7. INCO Limited (Thompson and Thompson Open Pit North)
8. Hudson Bay Mining and Smelting Co., Limited (Namew Lake)

Prospective Producers

1. New Quebec Raglan Mines Limited
3. Falconbridge Limited
   (Lindsley)
   INCO Limited (Clarabelle, Coleman, Garson, Crean Hill, Murray, Totten)
4. Teck Corporation (Moncalm Township)
5. Great Lakes Nickel Limited (Pardee Township)
6. INCO Limited (Shebandowan mine)
7. INCO Limited
   (Thompson Open Pit South, Soab North, Soab South, Birchtree, Pipe No. 1)

Smelters

3. Falconbridge Limited (Falconbridge)
   INCO Limited (Sudbury)
7. INCO Limited (Thompson)

Refineries

2. INCO Limited (Port Colborne)
3. INCO Limited (Sudbury)
7. INCO Limited (Thompson)
9. Sherritt Gordon Limited
   (Fort Saskatchewan)

Peat

M. PRUD'HOMME

Peat is an intermediate compound resulting from the biochemical decomposition of plant matter. In its raw material form, it is ligneous, fibrous and elastic. It has a pH of 2.8 to 4.0 and an ash content of 0.5 to 2.5%. Peat is composed of organic residues accumulated from the anaerobic decomposition of plant matters. Peat is found in peat bogs, swamps and marshes. Its main properties are its high water-retaining capacity, low density, high resistance to decomposition, low heat conductivity and high porosity. It can hold up to twenty times its weight in liquids and gas. Peat is divided into two principal types according to its botanical composition and degree of decomposition. Horticultural peat is relatively undecomposed, with a von Post value of H1 to H5. It has a high fibre content, is light yellowish brown in colour and contains few colloids. Fuel peat is highly decomposed, with a von Post value of H6 to H10. It is blackish in colour and contains colloid residues. Peat moss is the terminology given to commercial peat used in horticulture.

The total area of peatlands in Canada is estimated at 111 328 000 hectares (ha), covering close to 12% of the country's land surface. Approximately 60% of all Canadian peatlands are perennially frozen. Indicated peat resources total approximately 3 004 996 Mm^3, equivalent to 338 000 Mt of dry peat. Measured resources are estimated at 1 092 Mt.

Peat production in Canada is limited to a short harvesting season - from May to September due to weather conditions which hinder drainage and drying of the peat.

Canada mainly produces sphagnum peat, which is used in horticulture and agriculture. It is harvested primarily in eastern and southeastern Quebec, in northeastern and eastern New Brunswick, and in western Canada near Edmonton (Alberta), Carrot River (Saskatchewan), Giroux and Elma (Manitoba). A small amount of hypnum moss is also produced in Alberta and Ontario.

PRODUCTION AND TRADE IN CANADA

In 1988, Canadian peat production amounted to 725 000 t, a 10% decline from 1987, due to adverse climatic conditions that prevailed in May and August. The harvesting season from mid-May to mid-September was shorter than last year. In eastern Canada, frequent rain showers in June and August resulted in reduced output mainly in Quebec (24%) while production rose 6% in New Brunswick. Western Canada which accounted for 24% of total Canadian output, experienced fair weather conditions resulting in a production increase of 4%.

At the beginning of 1988, inventories were at a level almost 200% higher than in 1987 resulting in larger sales during the first half of the year. The 1988 value of shipments declined 5% to $70.6 million as the average unit value dropped 13% to $99.64/t, due to the aggressive pricing strategies of Canadian suppliers. Peat shipments were estimated at 708 000 t, a 10% increase over 1987. Quebec accounted for 40%, followed by New Brunswick (30%), Alberta (12%), and Manitoba; major gains were registered in eastern Canada and Manitoba.

Strong sales during the first half of 1988 resulted in a 50% reduction of inventories by the beginning of the harvesting season. Prices dropped by 14% due to a surplus in the market, large carry-overs of inventories from last year, and intense competition among Canadian suppliers.

Most Canadian peat production is used in horticulture, nurseries, landscaping and mushroom growers. Apparent consumption of peat is estimated at 12% of total shipments, the remainder being exported. Shipments

---

M. Prud'homme is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 992-3258.

comprise peat in bulk, bales and value-added products such as pots and mixes.

In 1987, exports reached 477 358 t, valued at $103 million, and were mainly from Quebec (35%), Ontario (23%), Manitoba (13%) and New Brunswick (11%). On a nine month basis in 1988, Canadian exports totalled 586 642 t, a 64% increase over 1987. The unit value of exports dropped 36% to $141.29/t, mostly due to a sharp drop in prices for deliveries in the United States.

The United States market accounted for 90% of Canadian peat exports, followed by Japan (7%).

From January to September 1988, Canada imported 199 t from the United States with a unit value of $206.03/t.

DEVELOPMENTS IN CANADA

In 1988, the Canadian peat industry provided employment to 1600 workers, a 4% growth from 1987. This estimate represents a record level of employment over the last 25 years, and accounted for close to 2.4% of total employment in the Canadian nonfuel mining industry, although employment in the peat industry was of a seasonal nature.

In western Canada, Premier CDN Enterprises Ltd. of Rivière-du-loup, Quebec, acquired the operations of Saskatchewan Minerals near Carrot River; the acquisition was part of a privatization plan pursued by the Saskatchewan Government. Premier Sask. Inc., a newly formed subsidiary will operate the facilities. In Alberta, Trade-tech Industries Ltd. brought on-stream a new peat moss operation at Alpen Siding, northeast of Edmonton. Premier CDN Enterprises Ltd. carried out exploration and development work on peat bogs in the Athabasca region. Hood Mfg. Enterprises Ltd. started harvesting peat moss with the vacuum method on a new bog near Evansburg. Lakeland Peat Moss Ltd. cleared new surfaces, experimented with vacuum harvesting and installed a new cellophane pelletizing system. Fisons Western Corporation expanded its harvesting acreages. In British Columbia, Northern Industries was sold to Hortech Soils which reported no production this year.

In central Canada, Lindeidt Peat Inc. commenced production at its peat bog in Marathon Township, 64 km from Cochrane in Ontario. In Quebec, Fafard & Brothers Ltd. of Saint Guillaume completed the development of a new peat moss operation at Saint-Ludger-du-Milot in the Saguenay-Lac-Saint-Jean area; the company has also acquired some shares of Tourbières Lambert Inc. of Riviere-Ouelle. Fafard & Brothers Ltd. carried out exploration work at the Sainte-Marguerite peat bog which is expected to be operated by Produits Desbiens Inc. Johnson & Johnson Inc. continued the renovation of the old Saint-Raymond paper plant at Desbiens, where the production of absorbent materials is expected to begin late in 1989. Tourbieres Verbois Inc. of Rivière-du-loup was acquired by La Tourbe du St-Laurent Ltée while Premier CDN Enterprises Ltd. acquired the operation of Tourbière Tardif Canada Inc.; incidentally, both operations are now part of the Premier group. The parent company also completed the construction of a new peat processing plant in Minnesota, United States.

La Société Tourbières Norbec Inc. conducted development work for the installation of a new peat plant in Port Cartier, and pursued tests for the manufacture of a peat-based activated carbon. The Bureau de Recherche sur l'Industrie de la Tourbe dans l'Est du Québec (BRITEQ) received government assistance to finance its activities; BRITEQ of Rivière-du-loup signed an agreement with l'Université du Québec à Rimouski (UQAR) to work jointly in applied research programs and contracts.

In Atlantic Canada, several producers carried out exploration and development work on new peat bog leases in various regions: in Nova Scotia near Shubenacadie; in New Brunswick: Burnt Church Peat Moss Co. Ltd. in Northumberland county, Fafard Peat Moss Company Ltd. in Kent county near Stonehaven, Malpec Peat Moss Ltd. in Kent county, and Berger Mix Inc. near Escuminac.

Late in 1988, Premier CDN Enterprises Ltd. of Rivière-du-loup, Quebec was granted an exploration permit on the Bull Pasture peat bog in the district of Sunbury near Fredericton.

Fafard Peat Moss Company Ltd. announced the construction of a new peat mix plant at its operations in Gloucester county; the company also acquired the assets of Burnt Church Peat Moss Co. Ltd. near Burnt Church. Fisons Western Corporation installed a professional mix facility at Lameque. Heveco Ltd. completed an expansion at its peat processing plant at Tabusintac. Acadian Peat Moss (1979) Ltd.

continued the development of a new peat operation, Miramichi Peat Moss Ltd. at Saint-Marguerite. Lameque Peat Moss Ltd. bought the peat facilities of Atkins & Durbrow (N.B.) Ltd. in Gloucester county. St-Ralphael Peat Moss Ltd. carried out some research and tests on a peat-based organic compost containing fish and crab wastes.

The Peat Research and Development Centre in Shippagan was awarded a contract to conduct research into peatland reclamation to help governments develop guidelines for the future restoration of abandoned production bogs; the project was sponsored by the New Brunswick Department of Natural Resources, and Energy, Mines and Resources Canada.

Late in 1988, the initiative of some Canadian producers of peat moss led to an agreement among most of the producers to establish a new national association. The objectives of the Canadian Sphagnum Peat Moss Association are to promote the sales of peat and peat products in North America and to share pertinent information of common interest, i.e. credit reporting, currency management, transportation issues, product liability and packaging. The activities of the association will cover promotional campaigns, market assessments and educational programs.

WORLD PRODUCTION AND FOREIGN TRADE

In 1987, world peat production amounted to 229 Mt, a 7% increase over 1986. Agricultural peat production accounted for 85% of world output. The 1988 world production has been forecast to grow by 5% to 241 Mt. The U.S.S.R. remained the largest producer of agricultural peat with a 97% share; Canada ranked fourth, with a 0.4% share.

United States

Peat production in the United States continued to expand for the second consecutive year; in 1988, production grew 10% to 950 000 t, valued at US$24 million. Ninety-five operations were active in 22 states, mainly Florida, Michigan, Illinois, Indiana and Minnesota; about 24 producers were reported selling potting soil mixes. Apparent consumption rose 7% to 1.5 Mt of which 36% came from Canada. Sphagnum peat moss accounted for only 5% of total domestic production which was dominated by seed-sedge (60%) and humus peat (30%). Domestic prices on an f.o.b. basis fell 15% to US$21.05/t. Canadian deliveries rose 20% in volume but dropped 10% in terms of unit value on a c.i.f. basis.

The American market for sphagnum peat moss was estimated at 580 000 t, a 20% increase over 1987. A 1% growth in this huge market would amount to an increase in production or shipments of close to 170 000 bales (170 dm^3/b), equivalent to the annual production of a small to medium size operation in Canada.

Japan

Japan is the second largest importer of Canadian peat moss, accounting for 7% of total Canadian peat exports in 1988. In 1987, Japan imported about 38 000 t of peat, a 19% increase over 1986. Canada remained the leading supplier with more than a 90% share of total imports, followed by the U.S.S.R. (5%); however, the unit value of imported peat from the U.S.S.R. was half that from Canadian origin. Sphagnum peat moss is mostly used in rice cultivation, horticulture, gardening and landscaping. During 1988 Canadian exporters faced two significant increases in ocean freight charges for peat deliveries to Japan. Moreover, the growth in demand is expected to decline slightly from the previously forecast rate of 10% due to a maturing of the market, while the pricing structure is expected to depress as a result of stiffer competition between Canadian exporters, and large inventory carry-overs.

U.S.S.R.

In the U.S.S.R. annual peat production averages 230 Mt of which 65% is reported to be used in agriculture and in the production of methanol. Most of the remainder is used as fuel in thermal power stations or made into briquettes (10%). Peat as a fuel is mainly used in the Urals and Western Siberia. In agriculture, peat is used on soils, in hothouses and as litter for livestock. Current known reserves of peat moss are estimated at 190 billion t, equivalent to 60% of world peat resources; the bulk of these reserves is located in the Russian Republic. There are no peat imports but the U.S.S.R. exports close to 300 000 t/y of milled peat in compressed bags. Major markets are in Western Europe (West Germany, Austria, France, the Netherlands, Italy, Belgium and Greece), in Oceania (Australia), and in Asia (Japan).

USES

Sphagnum peat is extracted from peatlands and dried. After the fibres are removed, it is pressed into bales. It is marketed in three forms. In its natural state, peat is sold in bulk form within a 100 km radius of production centres. When packaged in bags or bales, peat is compressed using a ratio of 2:1. The most common bale sizes are 170 dm^3 (6 ft^3), 113 dm^3 (4 ft^3), and 56 dm^3 (2 ft^3). Peat is mixed with fertilizers and other products, such as vermiculite and perlite, to form a substrate, and with limestone, soil and fertilizers to form potting soil.

Because of the range of its physical and chemical properties, peat has many uses. It is used in its natural state in agriculture and horticulture to loosen up clay soils, to maintain moisture in sandy soils and to add organic matter and fertilizers to depleted soils. Peat is also used as a horse, cattle and poultry litter to absorb liquids and odours. Peat is used in the production of artificial mixtures such as potting soil, seed carriers, peat-perlite and peat-vermiculite mixes, fertilizers and composts. It is used in the production of peat pots for sprouting plants.

Peat has several industrial applications. It can be used in the production of paper towels, chemical products, metallurgical coke and activated carbon (charcoal). Peat is also used to purify industrial and residential effluents. Its cellular structure, absorbing properties and high capacity for ionic exchange constitute adequate qualities for it to be used as a natural filter. Peat can reduce the acidity of drainage from old mines and remove iron oxydes from waste and drainage water. Peat acts as an aid for therapy in balneology, gynaecology and rheumatology. Peat moss has been used as an oil spillage absorbent and in medical tampons.

Fuel peat is recognized as an alternate source of energy. This form of biomass is widely used as fuel in several European countries, such as Ireland and Finland, and in the U.S.S.R. The calorific value of dry Canadian peat is approximately 4 700 to 5 100 kcal/kg, compared with oil at 9 900 to 10 000 kcal/kg and coal at 4 800 to 5 800 kcal/kg. Peat, as a fuel, is fired in furnaces to produce the steam needed to drive turbines generating electricity. Fuel peat can be processed to produce coke, synthetic natural gas and methanol. Fuel peat has a high degree of humification, a high bulk density, a high calorific value, a low ash content, and a low percentage of pollutants such as sulphur and mercury.

OUTLOOK

The buyer's market conditions that prevailed in 1988 are expected to recover to a more balanced situation during 1989 as inventories drop; the reduction in production in 1988 may result in firmer prices in the first quarter of 1989.

Canadian peat production is forecast to grow over the next few years due to increases in bog acreages in all producing regions. The manufacture of peat-based value-added products such as growing mixes will also increase as new plants are expected to come on-stream in the 1989-90 period.

The structure of the Canadian peat moss industry will continue to be concentrated and integrated as economies of scale and product differentiation allow companies to offset lower netbacks on sales resulting from higher freight charges, increased costs and stronger competition from substitutes; however, consumers offer resistance to prices increases due to their perception of peat moss as a low cost and bulk commodity. Over the last decade, prices in constant 1977 dollars have demonstrated a regular decline eroding producers' profitability. The Canadian industry has been reacting by consolidating its operations. In the medium term, the fragmented state of the industry will likely be replaced by a more concentrated structure.

The major markets for Canadian peat remain North America and Japan. The United States will continue to dominate our export sales as a natural and huge market. Although this market is considered mature, potential growth could be realized by the development of the retail market where the benefits of peat moss have not yet been totally identified by consumers. Promotional activities could enhance acceptance and demand for sphagnum peat products. Moreover, demand for peat growing medium mixes is forecast to expand an annual rate of 10% over the next three years; Canadian peat producers are expecting to make strong gains in this market.

The Japanese market has grown significantly since 1985. The uses of peat moss are being expanded and should result in firm demand for the next few years. The 30% annual growth rate that has prevailed over the last three years is expected to stabilize at a reduced level.

Overseas markets remain difficult to penetrate for Canadian suppliers due to high freight and exchange rates. Markets in Western Europe, North Africa, the Middle East and Oceania offer potential for sales of custom-made or consumer-specific peat products. Canadian peat in bales will continue to face stiff competition from foreign suppliers; however, the development of peat products or quality standards may provide the incentives for consumers to use Canadian sphagnum peat moss.

TARIFFS

		Canada			United States
Item No.	Description	MFN	GPT	USA	Canada
2703.00	Peat (including peat litter) whether or not agglomerated	10.2%	6.5%	8.1%	Free
6815.20	Articles of peat	6.8%	4.5%	6.1%	4.4%

Sources: Customs Tariffs, effective January 1989, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of United States (First Edition Supplement 2) effective January 1, 1989.

TABLE 1. PRICES[1] IN UNITED STATES, BY TYPE OF PEAT, 1987

	Domestic			Imported[2]
Type	Bulk	Packaged or bales	Average	Total
	(U.S. dollars per short ton)			
Sphagnum moss	22.18	75.03	46.01	137.93
Hypnum moss	32.29	32.63	32.51	..
Reed-Sedge	21.76	37.08	31.00	..
Humus	13.68	30.91	16.83	..
Other	11.24	..	11.24	..

Source: U.S. Bureau of Mines, Peat, 1987.
[1] Prices are f.o.b. plant. [2] Average customs values.
.. Not applicable; f.o.b. Free on board.

TABLE 2. WORLD PRODUCTION OF PEAT, BY COUNTRY, 1983-87

Country	1983[r]	1984[r]	1985[r]	1986[p]	1987[e]
			(000 tonnes)		
Agricultural use					
U.S.S.R.[e]	180 000	180 000	180 000	180 000	190 000
West Germany	1 870	1 430	1 515	2 015	2 175
United States	640	715	750	830	865
Canada	530	500	645	740	720
Netherlands[e]	400	450	450	400	400
Finland[r]	275	225	340	350	350
France[e]	110	225	200	220	210
Poland[e]	200	200	200	200	200
Ireland	95	95	95	95	80
Hungary[e]	70	70	70	70	70
Sweden[r]	60	60	40	60	60
Spain	40	55	55	50	50
Denmark	30	30	40	50	50
Norway[r]	30	30	30	30	30
Israel	20	20	20	20	20
Other	1 225	1 235	1 235	1 210	310
Total	185 595	185 340	185 685	186 340	195 590
Fuel use[1]					
U.S.S.R.[e]	25 670	17 505	15 965	19 500	24 035
Ireland	6 650	7 935	2 630	5 050	5 745
Finland	3 355	2 710	3 140	3 175	3 175
West Germany	260	275	285	245	245
Other	195	215	205	200	200
Total	36 130	28 640	22 225	28 170	33 400
World total	221 725	213 980	207 910	214 510	228 990

Sources: U.S. Bureau of Mines, Peat, 1987; Energy, Mines and Resources Canada.

[1] Fuel use figures have been highly revised for U.S.S.R.

[p] Preliminary; [r] Revised; [e] Estimated.

TABLE 3. CANADA, PEAT SHIPMENTS BY PROVINCE, 1984-88

Province	1984		1985[1]		1986		1987		1988P	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
	(000 t)	($ 000)	(000 t)	($ 000)	(000 t)	($ 000)	(000 t)	($ 000)	(000 t)	($ 000)
Newfoundland	1	44	1	121	2	149	1	45	2	102
Prince Edward Island	4	1 109	x	x	x	x	x	x	x	x
Nova Scotia	5	1 424	9	1 600	x	x	x	x	x	x
New Brunswick	151	10 974	175	14 700	228	21 351	197	18 917	214	18 292
Quebec	234	17 171	294	21 868	334	30 059	274	25 731	291	22 371
Ontario	5	733	6	755	x	x	x	x	x	x
Manitoba	71	9 837	87	10 563	x	x	x	x	x	x
Saskatchewan	10	1 335	11	1 601	x	x	x	x	x	x
Alberta	49	7 555	56	12 454	72	13 930	78	15 221	86	15 554
British Columbia	11	1 634	4	110	x	x	-	-	-	-
Total	541	51 816	643	63 772	738	80 152	648	73 996	708	70 562

[1] Shipments of peat for Prince Edward Island are included in Nova Scotia.
P Preliminary; - Nil; x Confidential.

TABLE 4. CANADIAN, DOMESTIC EXPORTS OF PEAT, BY COUNTRY, 1984-88

Country	1984		1985		1986		1987		1988P Jan.-Sept.	
	Tonnage	Value ($ 000)	Tonnage	Value ($ 000)	Tonnage	Value ($ 000)	Tonnage	Value ($ 000)	Tonnage	Value ($ 000)
Anguilla	-	-	-	-	-	-	-	-	1	2
Australia	83	54	10	9	61	32	480	251	2 051	1 062
Austria	-	-	-	-	-	-	-	-	161	72
Barbados	-	-	20	8	-	-	104	11	5	6
Belgium	-	-	-	-	-	-	-	-	486	144
Bermuda	86	40	70	22	40	15	52	13	66	33
Chile	-	-	8	2	-	-	-	-	-	-
China	-	-	-	-	-	-	-	-	25	3
Costa Rica	247	113	85	12	11	3	-	-	16	6
Cuba	-	-	5	3	1	2	-	-	-	-
Denmark	128	137	-	-	-	-	53	26	27	69
Dominican Republic	-	-	-	-	35	15	14	2	14	6
Egypt	-	-	-	-	-	-	27	15	404	162
Emirates, U.A.	30	8	-	-	-	-	-	-	-	-
Finland	-	-	-	-	-	-	7	1	-	-
France	-	-	-	-	-	-	9	5	19	27
Germany West	47	63	11	5	35	14	10	4	502	182
Greece	-	-	-	-	-	-	64	33	1 220	425
Greenland	-	-	14	8	38	7	18	7	-	-
Haiti	55	26	92	71	143	121	49	33	29	31
Honduras	-	-	30	23	-	-	-	-	-	-
Hong Kong	52	13	20	3	116	18	237	55	-	-
Iceland	-	-	-	-	-	-	-	-	9	2
India	-	-	17	1	-	-	-	-	-	-
Ireland	-	-	-	-	-	-	11	3	0	0
Israel	-	-	-	-	-	-	63	16	378	97
Italy	-	-	-	-	-	-	17	5	265	68
Japan	20 717	4 218	21 029	4 823	31 552	7 240	35 008	7 659	42 372	8 682
Korea South	30	7	30	7	50	12	67	16	110	33
Kuwait	-	-	265	82	-	-	40	27	-	-
Leeward-Windward Islands	-	-	6	1	12	6	22	10	-	-
Mexico	-	-	-	-	-	-	-	-	57	13
Namibia	-	-	-	-	-	-	-	-	21	4
Netherlands	-	-	-	-	17	5	204	45	2 526	501
Netherlands Antilles	19	5	-	-	-	-	-	-	13	6
Niger	-	-	-	-	-	-	-	-	139	31
Norway	-	-	-	-	-	-	11	2	47	18
Panama	22	14	22	8	-	-	-	-	-	-
Puerto Rico	822	223	1 339	264	2 138	553	1 736	536	1 684	515
St. Kitts-Nevis	-	-	-	-	-	-	-	-	19	4
St. Lucia	-	-	-	-	-	-	-	-	73	38
St. Pierre and Miquelon	-	-	-	-	209	38	-	-	-	-
Saudi Arabia	912	269	77	20	576	217	299	55	3 589	1 141
Singapore	-	-	15	6	16	7	64	26	-	-
South Africa	397	150	321	81	299	59	300	68	360	110
Spain	-	-	-	-	-	-	-	-	100	11
Switzerland	-	-	-	-	-	-	-	-	56	50
Taiwan	-	-	24	6	-	-	108	37	150	62
Trinidad - Tobago	88	39	63	51	46	15	29	19	15	6
United Kingdom	19	5	-	-	-	-	3 426	960	510	158
United States	436 845	76 818	422 937	78 446	499 600	101 574	434 813	93 279	529 123	69 108
Virgin Islands	-	-	11	6	-	-	-	-	-	-
Total	460 599	82 202	446 521	83 668	535 003	109 953	477 342	103 219	586 642	82 888

Source: Statistics Canada.
P Preliminary; - Nil.

TABLE 5. PRIMARY DESTINATIONS FOR CANADIAN PEAT DELIVERIES FROM MAJOR PRODUCING REGIONS IN 1986

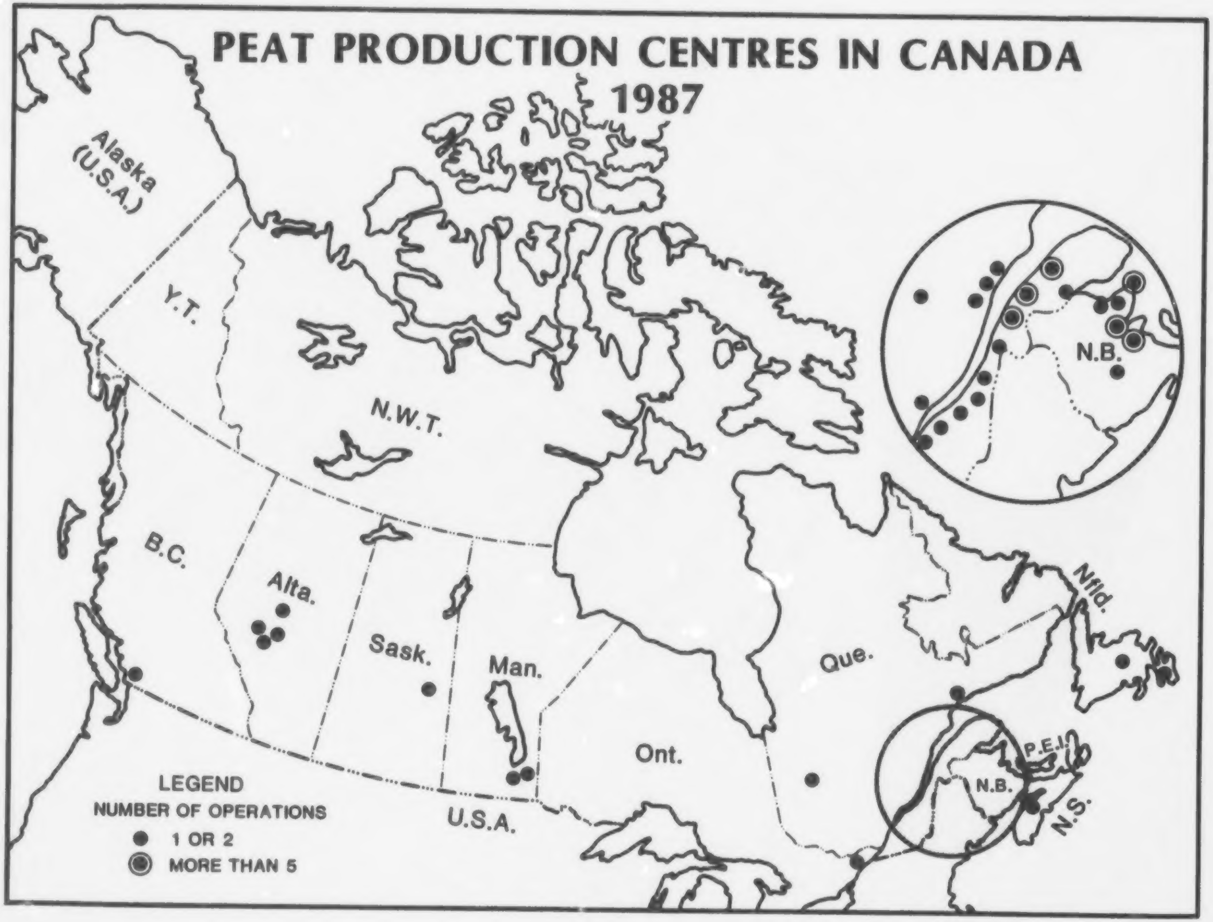
	Canadian Producing Region		
Destinations	Western Canada[1]	Central Canada[2]	Atlantic Canada[3]
		(tonnes)	
Western Canada[1]	18 140	110	185
Central Canada[2]	0	59 490	49 814
Atlantic Canada[3]	0	1 090	9 544
Sub-Total, Canada	18 140	60 690	59 543
United States	135 740	276 830	161 645
Japan	520	850	23 110
Other	0	1 635	0
Sub-Total, exports	136 260	279 315	184 755
Total	154 400	340 005	244 298

[1] British Columbia, Alberta, Saskatchewan and Manitoba. [2] Ontario and Quebec. [3] New Brunswick, Prince Edward Island, Nova Scotia and Newfoundland.

TABLE 6. PEAT RESOURCES OF CANADA

	Peatland Areas		Indicated Volume of Peat (Oven Dry)
	Ha x 10^3	% of Total Canadian Peatlands	Tonnes x 10^6
Newfoundland - Labrador	6 429	6	24 945
Prince Edward Island	8	...	30
New Brunswick	120	...	466
Nova Scotia	158	...	613
Quebec	11 713	11	40 057
Ontario	22 555	20	77 138
Manitoba	20 664	19	58 893
Saskatchewan	9 309	8	26 532
Alberta	12 673	11	36 118
British Columbia	1 289	1	4 410
Northwest Territories	25 111	23	65 841
Yukon Territory	1 298	1	2 960
Total	111 328	100	338 003

Source: "Peat Resources of Canada", C. Tarnocai, Agriculture Canada, NRCC 24140, 1984.
... Amount too small to be expressed; Ha hectare.



PEAT PRODUCTION CENTRES IN CANADA
1987

Alaska (U.S.A.)
Y.T.
N.W.T.
B.C.
Alta.
Sask.
Man.
Ont.
Que.
Nfld.
N.B.
P.E.I.
N.S.
U.S.A.
N.B.
LEGEND
NUMBER OF OPERATIONS
● 1 OR 2
◉ MORE THAN 5

Phosphate

G.S. BARRY

INTRODUCTION

Naturally occurring rock deposits are the most common source of phosphorus; other sources are bones, guano, and some types of iron ores that yield by-product basic slag containing sufficient phosphorus to warrant grinding and marketing.

Phosphate rock contains one or more suitable phosphate minerals, usually calcium phosphate, in sufficient quantity for use, either directly or after beneficiation, in the manufacture of phosphate products. Sedimentary phosphate rock, or phosphorite, is the most widely used phosphate raw material. Apatite, which is second in importance, occurs in many igneous and metamorphic rocks.

Phosphate rock is graded either on the basis of its P_2O_5 equivalent (phosphorus pentoxide) or its $Ca_3(PO_4)_2$ content (tricalcium phosphate of lime or bone phosphate of lime - TPL or BPL). For comparative purposes, 0.458 unit P_2O_5 equals 1.0 unit BPL, and 1 unit of P_2O_5 contains 43.6% phosphorus.

Approximately 88% of world phosphorus production goes into fertilizers; other products which require the use of phosphorus include organic and inorganic chemicals, soaps and detergents, pesticides, insecticides, alloys, animal-food supplements, motor lubricants, ceramics, beverages, catalysts, photographic materials, and dental and silicate cements.

In 1988 world phosphate rock production was estimated at 158 Mt, or about 12 Mt higher than in 1987. Comparison with previous years must be done cautiously as for the last two years there was a downward revision of some 3 Mt for production in China. Stocks held by major western world producers were 17.0 Mt at the end of September 1988 compared to 19.1 Mt a year before. There were increases in deliveries from all major phosphate producing and exporting countries except Israel, Jordan and Christmas Island. The later ceased production. There was a substantial increase in Moroccan production of over 3.0 Mt while U.S. production recovered to 51 Mt from only 41 Mt in 1987.

OCCURRENCES IN CANADA

Known Canadian deposits are limited and fall into three main categories: apatite deposits within Precambrian metamorphic rocks located in eastern Ontario and southwestern Quebec; apatite deposits in some carbonate-alkaline complexes (carbonatites) in Ontario and Quebec; and Late Paleozoic - Early Mesozoic sedimentary phosphate rock deposits in the southern Rocky Mountains. Phosphatic mineralization was also reported in the layered rocks of the Athabasca series.

The deposit of greatest economic significance is the Kapuskasing (Cargill) phosphate deposit, where early studies indicated the presence of about 60 Mt of ore grading 20.2% P_2O_5. It has been determined that the deposit contains higher grade sections totalling 22 Mt grading 27% P_2O_5. The best part of the deposit, contains 6 Mt grading 33% P_2O_5. This ore will need only minor concentration.

Another important carbonatite deposit was discovered in 1982 near Martison Lake north of Hearst, Ontario. Higher grade zones of the deposit contained 57 Mt grading 23% P_2O_5.

In July 1984, Sherritt Gordon Limited, Campbell Resources Inc. and New Venture Equities Ltd. combined to form a joint venture on two phosphate properties at Cargill and Martison Lake in Ontario. In 1987, Jacobs Engineering Group Inc. and Blue, Johnson and Associates completed a feasibility study for the Ontario Ministry of Northern Development and Mines. The study concluded that the deposit may become the basis for a viable mining operation of

---

G.S. Barry is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 992-7568.

approximately 500 000 t/y in the 1990s when supply and demand are in balance and phosphate rock prices have improved substantially.

CANADIAN PHOSPHATE INDUSTRY

Phosphate Rock and Phosphate Fertilizers

In 1987, Canada imported 1.97 Mt of phosphate rock. For the first ten months of 1988 imports were only 1.208 Mt. The recent closures of two phosphatic fertilizer plants were responsible for the lower import levels. By the end of 1988 Canada's wet phosphoric acid capacity declined to 647 300 t P_2O_5. Production of acid in 1988 was 474 609 t P_2O_5 equivalent.

About two-thirds of the phosphate rock is imported for fertilizer production and the remainder for elemental phosphorus.

Since the late 1970s, about 70% of Canada's imports of phosphate rock from the United States has been from Florida. The remainder was from western states. Lately the industry in western Canada has been experimenting with phosphate rock from other sources, principally Morocco and Togo. A significant shift of imports away from U.S. suppliers occurred in 1988, when the largest user of rock decided to import all of its requirements from Togo under a long term contract.

Brunswick Mining and Smelting Corporation Limited through its Smelting and Fertilizer Division (formerly Belledune Fertilizer), produced approximately 137 400 t of di-ammonium phosphate (DAP) in 1988 at its New Brunswick fertilizer plant from rock imported from Florida. The plant was shut in June for about 2 1/2 months for inventory control and maintenance. It was converted to the hemihydrate process in 1986. In 1988, the plant changed to propane fuel which caused some temporary production difficulties.

Cominco Ltd. produced slightly less than 200 000 t of phosphatic fertilizers in 1988 (MAP and 16-20-0) from its Trail plant in British Columbia. The Kimberley plant was shut down permanently in 1987. Cominco's mine in Montana is the main supplier of rock for the Trail plant.

Sherritt Gordon Limited ran its Fort Saskatchewan plant nearly at full capacity throughout 1988 using Florida rock.

Esso Chemical Canada operated its large Redwater plant at a steady rate throughout 1988. In fact, the plant produced at above rated capacity for some months. Until 1987, the company used mainly Florida phosphate rock but lately completed extensive studies on rock from Togo and Morocco. A decision was made in mid-1988 to sign a 5-year contract for the exclusive supply of Togo rock.

The dihydrate phosphoric acid plant was designed to operate on phosphate rock which grades between 69 and 72% BPL (31.1 to 33.0% P_2O_5); it had to be modified, at a cost exceeding $1.0 million, to operate on the much higher grade Togo rock.

Western Co-operative Fertilizers Limited's (WCFL) Calgary plant ceased operation on an indefinite basis on August 25, 1987. The plant will be mothballed and kept in operational order until there is a major market improvement.

Total Canadian phosphoric acid operating capacity at the end of 1987 was 647 300 t/y (100% P_2O_5 equivalent). Three of the remaining operating Canadian phosphate fertilizer plants produce wet phosphoric acid by the dihydrate process in which 28-30% P_2O_5 acid is the principal product and gypsum is the waste product. One plant was converted to a hemihydrate operation.

All phosphoric acid plants in Canada are integrated to produce phosphatic fertilizers, mainly ammonium phosphates. Ammonium phosphates are produced by a neutralization reaction of phosphoric acid with ammonia and, depending on the proportions of the original constituents, either diammonium phosphate (DAP) (18-46-0) or monoammonium phosphate (MAP) (range from 11-48-0 to 11-55-0) are produced. Another common grade particularly in the west is the 16-20-0.

Elemental Phosphorus

Tenneco Canada Inc., a subsidiary of Tenneco, Inc. controls the elemental phosphorus producer Albright & Wilson Americas (A&WA). The company operates two thermal reduction plants in Canada where elemental phosphorus is produced by the smelting of a mixture of phosphate rock, coke and silica. One tonne of phosphorus requires the input of about 10 t of phosphate rock (60 to 67% BPL), 2 t of coke and 3 t of silica. Energy consumption is about 13 000 kWh/t of phosphorus.

Albright & Wilson Americas has plants at Varennes, Quebec with a 22 500 t/y capacity of elemental phosphorus (P_4) and at Long Harbour, Newfoundland with an effective capacity of about 60 000 t/y. The elemental phosphorus production from Long Harbour is in a large part destined for Albright & Wilson, Ltd.'s derivative plants in Europe, with some exports to the United States. A proportion was sent to Port Maitland, Ontario to supplement supplies from Varennes, Quebec. The Long Harbour plant operated at approximately 75% of its 60 000 t/y capacity. Both furnaces were operating throughout the year. The plant was closed for vacation and maintenance for 3 weeks in the summer. The Varennes plant in Quebec operated at approximately 81% of its 22 500 t/y capacity.

Thermal phosphoric acid, the main derivative of elemental phosphorus is being replaced by "purified" wet process phosphoric acid. Thus technical obsolescence forced A&WA to announce that the Long Harbour plant will be closed permanently in 1989. Employment loss will be 260 out of 290.

The two A&WA phosphorus plants use about 600 000 t/y of Florida phosphate rock. Since the low-grade phosphate rock acceptable for thermal reduction cannot be used by the fertilizer industry, it can be purchased at relatively lower prices (per P_2O_5 unit value).

The elemental phosphorus produced at Varennes is shipped to two processing plants, one at Buckingham, Quebec and the other at Port Maitland, Ontario. At Buckingham, about 9 000 t/y of P_4 is used to produce technical and food grade phosphoric acid (95% H_3PO_4) and 1 000 t/y to produce amorphous red phosphorus.

A&WA's Port Maitland plant operates on phosphorus from Varennes and Long Harbour, using between 13 000 and 14 000 t/y.

Coproducts of elemental phosphorus are ferrophosphorus, carbon monoxide and calcium silicate slag. Ferrophosphorus contains 20 to 25% phosphorus and is used by the steel industry as a direct source of phosphorus needed for producing certain types of steel.

PRICES

Most phosphate rock is purchased at prices negotiated between consumers and producers which differ from listed prices in consideration of volume, transportation conditions and local competitive conditions. The average unit price of phosphate rock sold or used in the United States for domestic consumption was US$18.75/t f.o.b. mine in the fertilizer year ending June 30, 1988 and that of exported rock was US$24.08/t. This compares to US$21.11/t and US$23.78/t in 1987 which indicates a persistent weakness in domestic markets but a small improvement in export markets. Export prices showed a further improvement to US$26.00/t by the end of the year.

OUTLOOK

The outlook for 1989 is for a continuation of demand at the current levels, ample supply and prices that will improve moderately from the low levels of 1988. Significant price improvements will not occur until supply and demand approach a balance, which may not be before the 1991-92 period. A leading consulting firm forecasts a rapid increase in price after that interval to approximately US$45/t in 1995 (basis 70% bone phosphate of lime) from the current US$26.00/t f.o.b. vessel Tampa. At such prices a deposit such as Cargill could become a viable development.

A 1988 OECD publication "World Phosphates Supply to the Year 2000" forecasts that world consumption should rise from 36.2 Mt P_2O_5 in 1981 to 71.4 Mt in 2000 for a growth rate of 3.6%/y. Since the 1987 consumption is currently estimated at 41.0 Mt, the growth rate for the remaining interval, 1987-2000 would be 4.4%/y. This rate compares with a range of 2.6% to 3.0% which is accepted as more realistic by the writer and is also compatible with those currently projected for nitrogen and potash.

TABLE 1A. CANADA, PHOSPHATE ROCK IMPORTS, 1986 AND 1987, AND CONSUMPTION, 1985-87

	1986^r		1987	
	(tonnes)	($000)	(tonnes)	($000)
Imports				
United States	2 255 380	92 790	1 622 671	59 626
Togo	36 722	2 645	257 930	12 423
Morocco	63 580	1 921	72 624	719
Saudi Arabia	-	-	15 000	222
Total	2 355 682	97 356	1 968 225	72 990

	1985	1986	1987
		(tonnes)	
Consumption[1]			
Eastern Canada	971 041	837 651	775 650
Western Canada	1 767 346	1 519 241	1 287 060
Total	2 738 387	2 356 892	2 062 710

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Available data as reported by consumers.
^{r} Revised; - Nil.

TABLE 1B. CANADA, PHOSPHATE ROCK IMPORTS AND CONSUMPTION, 1988P

		1988P Jan.-Sept.	
		(tonnes)	($000)
Imports			
2510.10	Natural calcium phosphates, aluminum calcium phosphates, etc., unground		
	United States	548 908	16 523
	Togo	446 460	26 786
	Morocco	62 305	2 195
	Senegal	14 400	220
	Total	1 072 073	45 724
2510.20	Natural calcium phosphates, aluminum calcium phosphates, etc. ground		
	United States	362 384	14 706
	Togo	35 606	2 154
	Morocco	20 749	736
	United Kingdom	15	25
	Total	418 754	17 621

	1988
	(tonnes)
Consumption^e	
Eastern Canada	929 080
Western Canada	1 250 670
Total	2 179 750

Sources: Statistics Canada; Energy, Mines and Resources Canada.
P Preliminary; ^{e} Estimated.

TABLE 2. CANADA, PHOSPHATE FERTILIZER SHIPMENTS, 1982-88[1]

	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88
			(tonnes P_2O_5 equivalent)			
Domestic markets:						
Atlantic provinces	29 443	24 965	26 894	20 360	(	(
Quebec	43 308	37 835	27 990	23 865	(58 632[2]	(438[3]
Ontario	71 959	79 160	52 843	39 287	(	(
Manitoba	81 907	90 529	92 092	90 354	77 856	86 342
Saskatchewan	153 784	195 170	182 017	184 306	163 352	153 599
Alberta	157 010	161 185	170 943	153 523	132 087	133 124
British Columbia	10 970	11 311	11 940	10 951	10 056	8 893
Total Canada	548 381	600 155	564 719	522 646	441 983	382 387
Export markets:						
United States	82 478	65 790	71 403	46 763	51 344	(
Offshore	715	4 652	12 743	17 021	9 427	(89 431
Total exports	83 193	70 442	84 146	63 784	60 771	89 431
Total shipments	631 574	670 597	648 865	586 430	502 754	471 815

Source: Canadian Fertilizer Institute.

[1] Fertilizer year: July 1 to June 30; not 100% industry coverage. [2] Atlantic provinces, Quebec and Ontario now disclosed as total only. [3] DAP data withheld to prevent individual disclosures.

Note: Totals may not add up due to rounding.

TABLE 3. CANADA, PHOSPHATE FERTILIZER PLANTS, 1988

Company	Plant Location	Annual Capacity (tonnes P_2O_5 eqivalent)	Principal End Products	Source of Phosphate Rock	Basis for H_2SO_4 Supply for Fertilizer Plants
Eastern Canada					
Belledune Fertilizer div. of Noranda Inc.	Belledune, N.B.	150 000	am ph	Florida	SO_2 smelter gas
		150 000			
Western Canada					
Cominco Ltd.	Trail, B.C.	77 300	am ph	Montana	SO_2 smelter gas
Esso Chemical Canada	Redwater, Alta.	370 000	am ph	Florida, Togo	Sulphur
Sherritt Gordon Limited	Fort Saskatchewan, Alta.	50 000	am ph	Florida	Sulphur
		497 300			
historical capacity:					
end of 1983		1 031 000			
end of 1984		913 000			
end of 1985		788 000			
end of 1986		698 000			
end of 1987		647 300			
end of 1988		647 300			

P_2O_5 equivalent - Phosphorus pentoxide equivalent; am ph Ammonium phosphates.

TABLE 4. CANADA, TRADE IN SELECTED PHOSPHATE PRODUCTS, 1988P

		1988P Jan.-Sept.	
		(tonnes)	($000)
Imports			
2835.25	Calcium hydrogenorthophosphate (dicalcium phosphate)		
	United States	18 250	7 491
	Other countries	746	662
	Total	18 996	8 153
2835.26	Calcium phosphates, n.e.s.		
	United States	30 620	11 128
	West Germany	145	110
	Total	30 765	11 238
Fertilizers			
3103.10.00.10	Superphosphates containing 22% or less by weight of phosphorus pentoxide (simple superphosphate)		
	United States	6 539	1 424
	Total	6 539	1 424
3103.10.00.20	Superphosphates containing more than 22% by weight of phosphorus pentoxide (triple superphosphate)		
	United States	29 196	6 915
	Total	29 196	6 915
3105.30	Diammonium phosphate in packages weighing less than 10 kg		
	United States	169 762	40 112
	Belgium	432	169
	Total	170 194	40 281
3105.40	Monoammonium phosphate and mixtures thereof with diammonium phosphate, in packages less than 10 kg		
	United States	140 576	36 646
	Belgium	1 677	872
	Netherlands	112	59
	West Germany	26	16
	Total	142 391	37 593
Chemicals			
2535.23	Trisodium phosphate		
	United States	282	309
	People's Republic of China	147	111
	Israel	94	65
	West Germany	6	6
	Total	529	491
2535.24	Potassium phosphates		
	United States	1 513	1 672
	Israel	194	201
	West Germany	61	70
	Netherlands	2	3
	Total	1 770	1 946
Exports			
3105.30	Diammonium phosphate in packages weighing less than 10 kg		
	United States	10 011	2 544
	Jamaica	4 508	1 354
	Total	14 519	3 898
3105.40	Monoammonium phosphate and mixtures thereof with diammonium phosphate, in packages less than 10 kg		
	United States	42 209	8 821
	Total	42 209	8 821

Source: Statistics Canada.
P Preliminary; n.e.s. Not elsewhere specified.

TABLE 5. WORLD PHOSPHATE ROCK PRODUCTION, 1985-88

	1985	1986	1987^{e}	1988^{e}
	(000 tonnes product)			
WORLD TOTAL	**148 839**	**144 211**	**146 054**	**158 510**
West Europe	**734**	**722**	**793**	**800**
Finland	510	527	553	560
Sweden	187	192	221	220
Turkey	37	3	19	20
East Europe	**34 200**	**34 436**	**34 800**	**35 000**
U.S.S.R.	34 275	34 436	34 800	35 000
North America	**50 835**	**40 300**	**40 900**	**51 000**
United States	50 385	40 300	40 900	51 000
Central America	**534**	**600**	**640**	**650**
Mexico	534	600	640	650
South America	**4 250**	**4 541**	**4 874**	**5 000**
Brazil	4 214	4 509	4 777	4 860
Colombia	24	27	34	40
Peru	12	5	63	100
Africa	**34 418**	**36 904**	**36 842**	**41 670**
Algeria	1 208	1 203	1 073	1 350
Egypt	1 074	1 272	1 103	1 150
Morocco/Sahara	20 737	21 178	20 955	24 500
Senegal	1 781	1 851	1 880	2 300
South Africa	2 484	2 991	2 623	2 700
Togo	2 452	2 314	2 644	3 400
Tanzania	21	10	18	20
Tunisia	4 530	5 951	6 390	6 100
Zimbabwe	131	134	156	150
Asia	**23 061**	**25 179**	**25 819**	**23 670**
China	6 974	9 500^{e}	9 000	9 000
Christmas Island	1 200	825	842	-
India	707	511	551	600
Iraq	2 000^{e}	2 000	2 000	2 000
Israel	4 076	3 673	3 798	3 300
Jordan	6 067	6 249	6 801	5 500
North Korea	500^{e}	500^{e}	500	500
Syria	1 270	1 606	1 986	2 400
Vietnam	250^{e}	300^{e}	320	350
Sri Lanka	17	15	21	20
Oceania	**1 541**	**1 529**	**1 386**	**1 370**
Australia	33	35	10	20
Nauru	1 508	1 494	1 376	1 350

Sources: Phosphate Rock Statistics, International Fertilizer Industry Association Ltd.; U.S. Bureau of Mines, Mineral Commodity Summaries.

^{e} Estimated; - Nil.

Note: Totals may not add up due to rounding.

Platinum Metals

G. BOKOVAY

The platinum group metals (PGMs) refer to six closely related metals: platinum, palladium, rhodium, ruthenium, iridium and osmium. These metals, among the scarcest of all metallic elements, commonly occur together in nature.

Platinum prices strengthened in the second half of 1988 as a result of buoyant demand in both the industrial and investment sectors and the perception of possible supply shortfalls. The announcement by Ford Motor Company that it had developed a platinum free automotive catalyst resulted in prices falling in mid-December. While this announcement could have some negative potential impact on platinum in the longer term, the outlook for this metal remains positive. On the other hand, the Ford announcement has boosted the prospects for the other PGMs particularly palladium, owing to their possible use as substitute materials in automotive catalyst applications.

For Canadian mining companies involved in exploration for platinum group metals, the likelihood of an improvement in the market for palladium is a positive development since many Canadian PGM deposits discovered to date have contained significantly more palladium than platinum.

SUPPLY: CANADIAN DEVELOPMENTS

The production of platinum group metals in Canada increased slightly in 1988 to 11 458 kg from 10 930 kg in 1987. The operations of INCO Limited and Falconbridge Limited in the Sudbury basin account for the bulk of Canadian production, but small amounts are also produced by INCO at Thompson, Manitoba and by Hudson Bay Mining and Smelting Co., Limited and Outokumpu Mines Ltd. at Namew Lake in Manitoba.

The Lac des Îles region, near Thunder Bay, Ontario, continues to be one of the most promising areas for PGM exploration in Canada. During 1988, Madeleine Mines Ltd. continued with the development of its optioned Lac des Îles property. While preliminary work at the mine site, including the erection of a concentrator, is at an advanced stage, a production decision has been delayed pending the conclusion of suitable arrangements for the processing of mill concentrate.

At Fleck Resources Ltd.'s Marathon, Ontario property, which is under option to Euralba Mining (Canada) Ltd., the latter company can earn a 51% interest by spending $2 million by May 31, 1989 and conducting a feasibility study.

Also in Ontario, work is continuing at the Big Trout Lake property, 650 km north of Thunder Bay, by a joint venture involving International Platinum Corporation, Degussa AG and Jenkim Holdings (Canada) Limited. Preliminary test results indicate PGM values of up to 9.6 g/t plus chromite layers grading up to 14% chrome oxide.

In Quebec, La Fosse Platinum Group Inc. continued to explore the Labrador Trough in 1988. In addition to several deposits which have been outlined in the Blue Lake area near Schefferville, La Fosse has reported new discoveries at properties in the Gerido mining division with PGM values of up to 7.5 g/t plus gold. La Fosse is conducting exploration for platinum near Chibougamau and Montebello, while Longreach Resources Ltd. is undertaking an exploration program near Temiskaming. Equinox Resources Ltd. and Technigen Corporation are proceeding with plans to bring their R.M. Nickel property, 18 km west of Rouyn-Noranda, into production. The deposit contains an estimated 130 000 t of ore grading 0.79% Cu, 0.46% Ni and high levels of platinum and palladium. Equinox estimates that the entire deposit can be mined over a six month period.

In Manitoba, International Platinum Corporation has several PGE properties including Fox River in the northeastern part of the province and Reed Lake in west-

---

G. Bokovay is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 992-4093.

central Manitoba. In Saskatchewan, the Kasner group of companies and Eldorado Resources Limited continued exploration work on several gold-PGM projects in the Beaverlodge area. On the basis of encouraging initial results, additional exploration will be undertaken. In British Columbia, Longreach Resources Ltd. and Placer Dome Inc. are conducting an exploration program at Longreach's Platinum Blonde gold-platinum property near Grand Forks. Longreach is also conducting work with Monica Resources Ltd. at the Grasshopper prospect in the Tulameen area. Historically, platinum was recovered from gold placer operations on the Similkameen and Tulameen Rivers.

In the Yukon, All-North Resources Ltd. (68% owned by Galactic Resources Ltd.) and Chevron Minerals Ltd. continued an exploration program at the site of the former Wellgreene nickel mine in the Kluane district, 350 km northwest of Whitehorse. Probable reserves have been calculated at 16.4 Mt grading 0.3% nickel, 0.7 g/t platinum, 0.4 g/t palladium and 0.5% copper.

In the Northwest Territories, International Platinum plus Equinox Resources Ltd. in conjunction with Technigen Corporation are involved in exploration programs on the Muskox Intrusion in the Coppermine River area. Elsewhere in the Northwest Territories, Asamera Minerals Inc. has undertaken extensive field work on a nickel/platinum/palladium prospect near Rankin Inlet.

SUPPLY: WORLD DEVELOPMENTS

There are three producers in the Republic of South Africa: Rustenburg Platinum Holdings Limited, Impala Platinum Holdings Ltd. and Western Platinum Limited. Rustenburg, the largest South African producer, operates three mines in the Bushveld complex, namely Rustenburg, Union and Amandelbult, and manages a fourth, Atok, for its affiliate Lebowa Platinum Mines Limited (formerly Atok Platinum Mines (Proprietary) Limited). Capacity of the Rustenburg operations, including Lebowa, is estimated at 65 300 kg/y of PGMs. Rustenburg's existing expansion plans are focused through or in partnership with Lebowa Platinum. This includes a major expansion of the Atok mine, which could increase production from 1 550 kg to 4 350 kg by 1992. Another 5 900 kg of output is expected from the first stage of the planned Maandagshock mine, planned to be on-stream in 1991. Should market conditions permit, another mine at Potgietersrus could also be developed in the 1990s. Rustenburg is also proceeding with the construction of a new PGM refinery in Bophuthatswana. Despite some construction delays the company expects to complete the project by June 1989.

Impala Platinum, South Africa's second largest PGM producer, operates four adjacent mines, namely Bafokeng North and South and the Wildebeestfontein North and South, and a refinery at Springs. Annual capacity is estimated at 52 900 kg.

Impala, through its wholly-owned subsidiary Gazelle Platinum Limited, is proceeding with the development of the Karee mine near Marikana. The site has about 130 Mt of Merensky ore reserves and 180 Mt of ore reserves on the UG-2 reef. The average grade from both zones is estimated at 5 to 5.5 g/t. The company plans to bring the mine on-stream in 1990/91 at a planned output of 3 100 kg/y of platinum, increasing eventually to 9 300 kg/y. At least part of the output from the Karee project will be used to offset the anticipated decline in output from Impala's existing operations.

Western Platinum Limited, owned by Lonrho plc, is the smallest South African producer with one mine in the Marikana District of the Transvaal to the east of the Rustenburg operation. PGM capacity is estimated at 8 500 kg/y although a current expansion will increase output to approximately 15 000 kg/y.

In addition to the expansions being undertaken by the three existing South African producers, as many as five additional mines may be developed in the medium term. Northam Platinum Limited, owned 72.6% by Gold Fields of South Africa Ltd., is proceeding with the development of a new PGM mine southeast of the Amandelbult section of Rustenburg Platinum. It is expected that production will begin in 1992 although the operation will not reach its full design capacity of up to 11 000 kg/y until 1994. The prospect is reported to have reserves totalling 163 Mt grading 10.1 g/t combined PGMs plus gold. Northam also plans to build a precious metals refinery. Completion of this facility is planned for 1995.

Rand Mines Limited, through its Barplats Investments Ltd. subsidiary, is proceeding with two new mine developments. The Lefkochrysos mine, which is near the town of Brits in the western Transvaal, is expected to begin production in 1989 and reach a planned first phase output level of about 8 700 kg/y of PGMs in the mid-1990s. During the initial production period, mining activity will be restricted to the UG-2 zone. UG-2 ore reserves at the site are estimated at 125 Mt grading 5.9 g/t PGMs plus gold. The second project is the Rhodium Reefs development in the eastern Transvaal. The project, which will initially exploit the UG-2 reef, is scheduled to commence production in 1991. Output from the mine is expected to be about 10 000 kg/y PGMs plus gold during the initial production period, increasing eventually to 15 500 kg/y. Ore reserves at Rhodium Reefs are reported to be 84 Mt on the UG-2 grading 6.28 g/t PGMs plus gold. An additional 48 Mt grading 3.9 g/t is contained in Merensky Reef ores at the site.

Another new South African PGM mine development is Messina Ltd.'s project in the northeastern Transvaal. This mine is expected to come on-stream in 1992 and reach a planned production capacity of approximately 8 400 kg/y of PGMs by 1993. Another possible PGM development is the proposed mine of Severin Mining and Development in the eastern Transvaal. While ore grades are quite good, the Merensky and UG-2 Reefs on this property are at significant depth.

The only PGM producer in Australia is Western Mining Corporation Limited which recovers small quantities of palladium and platinum as by-products from nickel mining operations. However, with significantly higher prices for platinum metals, exploration in Australia, like Canada, has intensified significantly in recent years. In Western Australia, Reynolds Metals Company is conducting a A$2.5 million exploration program at the Yarawindah Brook deposit, 120 km north of Perth. Grades of up to 4.4 g/t platinum, 5.2 g/t palladium and 1.2 g/t gold have been reported. Another promising project in Western Australia is the Munni Munni deposit of Hunter Resources Ltd. in the Pilbara area with grades of up to 4.3 g/t PGMs plus gold. In the South Alligator Valley of the Northern Territory, the Coronation Hill gold/platinum deposit is being explored by BHP Gold Mines Ltd., Noranda Australia Ltd. and Electrolytic Zinc Company of Australasia Ltd. On the basis of preliminary work, the companies have reported grades of 7.72 g/t gold and 1.76 g/t combined platinum and palladium. In the Fifield area of New South Wales, the site of limited PGM production at the turn of the century, Helix Resources NL has obtained values of up to 5.2 g/t platinum.

Exploration for PGMs is also taking place in New Zealand, Indonesia, and Papua New Guinea. Significant attention is also being given to PGM occurrences in Brazil, Greenland, Ecuador, the Republic of Ireland and Zimbabwe. In the case of the latter, Masasa Mines (Private) Ltd., a subsidiary of Delta Gold NL of Australia, is conducting a feasibility study on its Hartley Platinum Project on the Great Dyke. Drill indicated reserves have been estimated at 62.7 Mt grading 2.7 g/t Pt, 2.0 g/t Pd, 0.21% Ni and 0.14% Cu.

Recycling

The recovery of PGMs from secondary sources such as used industrial catalysts, electronic scrap and jewellery constitutes an important source of these metals in the western world. The U.S. Bureau of Mines estimates that recycling in the United States yielded approximately 42 000 kg in 1987, including some 7 500 kg recycled on a non-toll basis.

Spent automobile catalysts represent a growing and potentially significant source of PGMs. With higher metal prices in recent years, competition in the scrap industry has intensified for used converters. Johnson Matthey Public Limited Company estimated that scrap recovery of PGMs from automobile catalysts in 1988 would total 4 700 kg.

While the United States is the major source of PGM scrap from catalytic converters, it is estimated that between 65 and 75% of this material is refined offshore, primarily in Japan. The major recycler of used auto catalysts in the United States is Texasgulf Inc.

During 1988, Platinum Lake Technology Inc. of Toronto was reported to be proceeding with the construction of a pilot scale secondary recovery facility in Mississauga, Ontario. According to published reports, the plant will use a new hydrometallurgical leaching process, based on a proprietary chlorine-based reagent (CRO/REDOX system). The Canada Centre for Mineral and Energy Technology (CANMET) has been involved with Platinum Lake in the development of this technology. While initial tests will concentrate on the recovery of PGMs from catalytic scrap, the process could be used to recover PGMs from primary sources.

CONSUMPTION AND USES

Platinum group metals are used in a wide variety of applications in pure form and in a host of alloys combining different PGMs alone or with other metals. The diversity of uses reflects their varied and unique attributes which include: chemical inertness and corrosion resistance, the ability to catalyze chemical reactions, high melting points, high strength at elevated temperatures, stable thermo-electric properties, good durability, low coefficient of thermal expansion, excellent reflectivity, stable electrical contact resistance and good high temperature oxidation resistance. Platinum and palladium are the most common PGMs found in nature. Platinum's principal uses are in catalysts designed to control automobile exhaust emissions and in jewellery, while the main uses of palladium are in the electrical and electronics industries and also in dental alloys.

While the other PGMs are less important in absolute terms, rhodium, iridium and ruthenium have key industrial applications. The most important uses of rhodium are in automobile catalysts and as an alloying agent with platinum, while iridium is used in electrochemical and catalytic applications. The principal uses of ruthenium are electrochemical and electronic in nature. Osmium is used in the chemical and medical fields.

One of the largest uses of PGMs is in the production of automobile catalysts. There are two distinct types of auto catalysts, an oxidation type which controls carbon monoxide and hydrocarbons, and the so-called three-way type which controls emissions of carbon monoxide, hydrocarbons and nitrous oxides. Oxidation catalysts can contain either platinum or palladium although most use a combination of the two metals. On the other hand, three-way catalysts require platinum and rhodium, although they normally also contain palladium. The use of oxidation catalysts has diminished as new environmental regulations governing nitrous oxides have come into effect, but some automobile manufacturers utilize an oxidation catalyst in conjunction with a three-way catalyst. PGM catalytic units are currently the major technology being utilized to reduce hydrocarbon and nitrous oxide emissions in automotive exhaust gases, although research is continuing on alternative systems. Recently, Ford Motor Company of the United States reported that it had developed an alternative catalyst using unspecified material that is claimed to be as effective as platinum in meeting exhaust emissions. However, according to a patent filed by Ford, the new catalyst employs a member of platinum group in combination with cerium dioxide. It is believed that the most likely PGM to be utilized as a substitute for platinum would be palladium.

The largest market for automotive catalysts is the United States but the adoption of automobile emission standards across Europe will provide a significant boost to platinum demand. Emission control regulations, equivalent to 1983 U.S. standards, have already been adopted by Austria, Sweden, Norway and Switzerland. Within the European Economic Community (EEC), standards are being phased in over several years, beginning in October 1988 with all newly-designed car models with an engine displacement larger than two litres. Standards for new model cars with engine sizes of between 1.4 and 2.0 litres are scheduled to take effect in 1991. Automobiles with engine displacements of less than 1.4 litres will be required to meet minimum standards beginning in 1990. More stringent standards for this group, equivalent to the 1.4 to 2.0 litre category, have been proposed although a firm timetable for implementation has yet to be agreed upon. It should be noted that the adoption of the EEC regulations is voluntary by member countries. While it is believed that all will eventually endorse the established standards, there are several countries which have or may delay implementation, including France, Italy and the United Kingdom.

Automobile manufactures have the option of meeting EEC emission requirements in the smaller engines through a variety of means, including the so-called "lean burn" engine technology. However, it is expected that in order to meet the more stringent standards, most will utilize some form of catalytic converter.

Even before the actual adoption of emission standards in the EEC, demand for converter equipped automobiles has increased dramatically. It was reported that in West Germany, more than 50% of new cars have these devices.

The use of PGMs in jewellery, which constitutes the second largest use for platinum, is particulary large in Japan and has also been growing in Europe, especially in the Federal Republic of Germany. Despite higher dollar prices, the steady appreciation of the yen has allowed the demand for platinum jewellery in Japan to remain strong.

In the petroleum refining industry, PGMs, paticularly platinum, are used as reforming agents to increase the octane rating of gasolines. This use has become more important in recent years as more stringent environmental regulations have restricted the amount of lead additives in gasoline. These additives are known to reduce the effectiveness of PGM auto catalysts. Also in the refining industry, PGM catalysts are used in hydrocracking and isomerization applications.

One potential use, which could represent a major new market for platinum, is in the manufacture of fuel cells. There are several potentially promising applications for this technology, including stationary power generation systems. While development work for such systems is continuing, they offer significant advantages over traditional systems in terms of potential energy efficiency and speed of construction. Another potentially important use is in transportation, particularly urban buses.

In addition to uses by industry or in the manufacture of jewellery, there has been a rapid increase in recent years in the production of wafers, small bars, platinum coins and medallions in response to growing investment demand. During 1988, three new platinum bullion coins were introduced, the "Koala" in Australia, the "Maple Leaf" in Canada and a 150 rouble coin in the U.S.S.R. Beginning in 1987, the People's Republic of China issued a limited number of one ounce platinum coins known as the "Panda". Before the launch of these new coins, the most important bullion coin was the one ounce "Noble" from the Isle of Man, first introduced in 1983. For 1988, Johnson Matthey Public Limited Company has reported that the small investment products sector (products under 10 oz.) including coins will increase 67% over 1987 to approximately 11 000 kg.

In line with the Canadian government policy on apartheid, the Canadian "Maple Leaf" is being produced with metal from non South African sources. The Royal Canadian Mint stated that its first year sales target for the platinum "Maple Leaf" was 3 100 kg, the same as that projected for the Australian "Koala".

One of the largest markets for palladium is in the electronics industry, where it is used in the manufacture of multi-layer ceramic capacitors, thick-film hybrid integrated circuits, resistor networks and electrical contacts. Another important application and the fastest growing market for palladium is in the field of dentistry, where it is used in dental alloys and orthodontic and prothodontic devices. Much of this growth has resulted from the substitution of palladium for higher-priced gold.

MARKETS PRICES AND STOCKS

A new London terminal market (a market where physical delivery of metal takes place) was formed in 1987. In 1988, it was reported that this market would be expanded to eight international firms and to two daily formal fixes, similar to that already in existence for gold and silver. The eight companies, which are members of the "London-Zurich Good Delivery Agreement" include Samuel Montagu & Co., Ayrton Metals Ltd., Sharps Pixley Ltd., Mase Westpac Australia Ltd., Engelhard Corporation, Credit Suisse, Swiss Bank Corp., and Union Bank of Switzerland.

In December 1988, J. Aron & Company Inc. issued 10 000 platinum warrants, believed to be the first ever issue of its kind. Each warrant, which cost the equivalent of US$580/oz. can be converted into 5 oz. of platinum until June 23, 1990 at $590/oz.

Sales of PGMs by the U.S.S.R., which increased significantly in 1987, were estimated to have remained at similar levels in 1988. In the fourth quarter of 1988 it was reported that the Soviets were cutting back on their yearly commitments of platinum to dealers because of increasing domestic demand. It was also reported that Soviet traders were offering a six month palladium supply contract rather than the twelve month contract that was offered in recent years. Together with earlier reports that the amount of palladium sold under contract would be cut, it is thought that the Soviets may be trying to maximize PGM revenues by selling metal on the spot market when prices are high.

From a low of US$447.50/oz. in February, platinum prices climbed to $615.50 in June based partially on buoyant demand in Japan. Prices eased somewhat during the summer although they recovered in the fall due to strong demand and the possibility of serious supply shortfalls. Metal purchases for both the Canadian "Maple Leaf" and the Australian "Koala" coin programs have also been cited as contributing factors. In December prices plummeted from a high of $613 to $510, mainly as a result of the Ford Motor Company's announcement although there was some recovery in January with the price reaching $541.50.

Palladium price movements mirrored those of its sister metal throughout most of 1988. From a low to $115.75 in February palladium rose to $133.00 in June. Price levels declined through the summer reaching a low of $117.50 in September although they strengthened once again in the fourth quarter. The Ford statement in December provided a significant boost to prices in that there was considerable speculation linking palladium to the platinum substitute in automotive emission catalysts. As a result palladium prices increased significantly, reaching US$146/oz. on December 19. Prices moderated during the remainder of December but stabilized at about $132/oz. during the first half of January 1989.

The lesser known PGMs - rhodium, ruthenium, iridium and osmium - are produced in relatively small amounts. Collectively, this group constitutes about 15% of South African PGM production and about 10% of Canadian output. They are often characterized by thin trading and exaggerated price movements.

Speculative demand for rhodium, whose principal use is in automobile catalysts to control nitrous oxide emissions, has remained quite strong during the past several years in anticipation of the introduction of emission regulations within the EEC, beginning in 1988. This strength is also attributable to the fact that the ratio of platinum to rhodium in "three way" automobile catalysts may be as high as 5:1 compared with a Merensky ore ratio in South Africa of 20:1. Unlike platinum and palladium there was a significant improvement of rhodium prices during 1987 (from about US$1100 to $1250/oz.) and also much less volatility. Prices during the first half of 1988 were relatively stable at between $1225 and $1250. In July, rhodium prices fell to about $1150/oz. although they recovered to their former level in the second half of the year.

There was some erosion of prices of ruthenium, iridium and osmium during 1987 and 1988. Ruthenium prices, which began in 1987 in the $75-$80/oz. range, fell to $67-$71 by year-end while iridium prices fell from about $400 to $340 during the same period. Prices for osmium, the rarest member of the PGM group, slipped from a trading range of US$650-750/oz. at the beginning of 1987, to $590-$650 at year end.

During 1988, ruthenium prices continued to soften. In November 1988, price quotations were in the range of $60 to $64/oz. Similarly, iridium prices eased during 1988 to a range of $285 to $305 while osmium prices fell to a range of $580 to $625.

OUTLOOK

In view of the possible downturn in investment demand and the likelihood of reduced automobile sales in North America during 1989, some easing of the extremely tight supply situation for platinum is expected. Nevertheless it is forecast that prices will remain above US$480/oz. for the remainder of the year.

Notwithstanding some increases in PGM capacity, particularly in South Africa, and the possible development of effective alternatives for autocatalysts, the longer term outlook for platinum prices is positive in view of a 3.0 to 3.5% average annual rate of growth in demand predicted for the next decade. The major growth areas will continue to be the autocatalyst market, particularly in Europe, and also jewellery. Demand from the investment sector is expected to increase but this market will continue to be somewhat erratic owing to and perhaps contributing to platinum's greater volatility than gold. It is expected that the Ford statement in December 1988 will have some dampening effect on investment demand in the short-term.

While palladium could capture a larger share of the autocatalyst market, it is anticipated that platinum will retain its dominance for this application. In this regard, there is considerable skepticism that a palladium based catalyst can overcome problems associated with lead contamination and also meet more stringent environmental standards. According to Toyota Motor Corporation a palladium based catalyst is unsuited for high efficiency engines.

Demand for palladium in the important electronics sector, which increased significantly in 1987 and 1988, should continue to grow in 1989. A new palladium-based connector coating, which permits manufacturers to significantly reduce gold usage in electronic applications, has opened up enormous new market opportunities for palladium. In addition, the large market for palladium in dentistry should also continue to expand. Therefore, it is expected that palladium demand will match the 3.0-3.5% annual growth rate expected for platinum during the next decade.

New and stricter environmental controls on automobile emissions of nitrous oxides in the next decade will keep rhodium prices at or near recent highs despite efforts to increase the efficiency of rhodium utilization. In this regard, it is reported that autocatalyst manufacturers are striving to increase the platinum:rhodium ratio in three-way catalysts from 5:1 to at least 10:1.

Despite short-term fluctuations in PGM markets, there is excellent potential for rapid growth in the industry. This optimism has already stimulated significant new investment in PGM exploration around the world and particularly in Canada. Given its geological potential, promising exploration results and geopolitical factors, the Canadian PGM industry will undoubtedly become an even more attractive focus for investment in the years to come.

Canada appears to have significant potential for development of platinum group metals. It is expected that production will increase over the next few years as deposits, such as Lac des Îles, are developed. These deposits will be of much higher grade than those currently being mined in South Africa. As well, palladium to platinum ratios will be significantly higher.

TABLE 1A. PLATINUM METALS, PRODUCTION AND TRADE, 1986 AND 1987

	1986r		1987	
	(kilograms)	($000)	(kilograms)	($000)
Production[1]				
Platinum, palladium, rhodium, ruthenium, iridium	12 190	..	10 930	..
Exports				
Platinum metals in ores and concentrates				
United Kingdom	9 040	97 693	7 738	92 465
Other countries	22	503	25	246
Total	9 062	98 196	7 763	92 711
Platinum metals, refined				
United Kingdom	1 413	8 996	2 954	17 403
United States	2 126	21 170	1 164	6 902
Other countries	55	531	222	3 845
Total	3 594	30 697	4 340	28 150
Platinum metals in scrap				
United States	5 073	12 278	6 038	27 394
United Kingdom	490	3 906	85	498
West Germany	-	-	237	3 694
Other countries	109	1 116	31	799
Total	5 672	17 300	6 391	32 385
Imports				
Platinum lumps, ingots, powder and sponge				
United States	487	9 904	986	19 852
United Kingdom	295	5 543	103	2 327
Other countries	2	43	1	22
Total	784	15 490	1 090	22 201
Other platinum group metals				
United States	538	4 874	506	6 170
United Kingdom	442	3 440	297	2 327
Other countries	-	-	60	3 103
Total	980	8 314	863	11 600
Platinum crucibles[2]				
United States	665	20 001	706	22 295
Total	665	20 001	706	22 295
Platinum metals, fabricated materials				
United States	1 103	6 663	566	6 040
United Kingdom	369	6 103	123	2 583
France	-	-	26	300
Other countries	311	5 579	3	78
Total	1 783	18 345	718	9 001

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Platinum metals, content of concentrates, residues and matte shipped for export. [2] Includes spinners and bushings.

.. Not available; r Revised; - Nil.

Note: Numbers may not add to totals due to rounding.

TABLE 1B. PLATINUM METALS, PRODUCTION AND TRADE, 1988P

Item No.		1988P	
		(kilograms)	($000)
Production[1]			
Platinum, palladium, rhodium, ruthenium, iridium		11 458	..
Exports		(Jan.-Sept.)	
2604.00	- Nickel ores and concentrates		
2604.00.83	----- Platinum metals group content	-	-
26.16	Precious metal ores and concentrates		
2616.90	- Other		
2616.90.83	---- Platinum metals group content		
	United Kingdom	9 522	100 027
	Total	9 522	100 027
71.10	Platinum, unwrought or in semi-manufactured forms, or in powder form		
	- Platinum:		
7110.11	-- Unwrought or in powder form		
	United Kingdom	961	4 916
	United States	510	3 499
	West Germany	124	65
	Other countries	155	872
	Total	1 750	9 937
7110.19	-- Other		
	Hong Kong	234	4 588
	Other countries	15	262
	Total	249	4 850
	- Palladium:		
7110.21	-- Unwrought or in powder form		
	United Kingdom	315	1 669
	United States	125	605
	Total	440	2 275
7110.29	-- Other		
	Singapore	127	607
	United States	7	30
	Other countries	3	6
	Total	137	645
	- Rhodium:		
7110.31	-- Unwrought or in powder form		
	United Kingdom	321	11
	Total	321	11
7110.39	-- Other	-	-
	- Iridium, osmium and ruthenium:		
7110.41	-- Unwrought or in powder form	-	-
7110.49	-- Other	-	-
71.12	Waste and scrap of precious metal or of metal clad with precious metal		
7112.20	- Of platinum, including metal clad with platinum but excluding sweepings containing other precious metals		
	United States	30	10 505
	Other countries	9	1 613
	Total	39	12 118

TABLE 1B. (cont'd)

Item No.		1988P Jan.-Sept.	
		(kilograms)	($000)
Imports			
26.04	Nickel ores and concentrates		
2604.00.00.83	------ Platinum group metal content	-	-
26.16	Precious metal ores and concentrates		
2616.90.00	- Other		
2616.90.00.30	----- Platinum group metal content		
	United Kingdom	17	405
	Total	17	405
71.10	Platinum, unwrought or in semi-manufactured forms, or in powder form		
	- Platinum:		
7110.11.00	-- Unwrought or in powder form		
	United States	1 120	18 940
	U.S.S.R.	647	13 512
	South Africa	210	6 081
	United Kingdom	35	706
	Switzerland	1	11
	Total	2 013	39 250
7110.19.00	-- Other		
	U.S.S.R.	1 122	23 640
	United States	977	12 542
	United Kingdom	354	10 649
	Other countries	497	9 575
	Total	2 950	56 406
	- Palladium:		
7110.21.00	-- Unwrought or in powder form		
	United States	429	7 916
	West Germany	310	294
	United Kingdom	30	149
	Total	769	8 359
7110.29.00	-- Other		
	United States	489	3 054
	Canada	51	566
	Other countries	154	747
	Total	694	4 367
	- Rhodium:		
7110.31.00	-- Unwrought or in powder form		
	United States	267	3 381
	United Kingdom	16	594
	Total	283	3 975
7110.39.00	-- Other		
	United States	36	592
	United Kingdom	87	203
	Total	123	796
	- Iridium, osmium and ruthenium:		
7110.41.00	-- Unwrought or in powder form		
	United States	5	43
	Total	5	43

TABLE 1B. (cont'd)

Item No.		1988P Jan.-Sept.	
		(kilograms)	($000)
Imports (cont'd)			
7110.49.00	-- Other		
	United States	7	85
	Total	7	85
71.12	Waste and scrap of precious metal or of metal clad with precious metal		
7112.20.00	- Of platinum, including metal clad with platinum but excluding sweepings containing other precious metals		
	United States	678	13 780
	Total	678	14 196
71.15	Other articles of precious metal or of metal clad with precious metal		
7115.90	- Other		
7115.90.10.20	----- Crucibles of platinum		
	United States	836	23 867
	Total	837	23 870
7115.90.90	--- Other		
7115.90.90.30	----- Of platinum		
	United States	33	633
	Total	33	633

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Platinum metals, content of concentrates, residues and matte shipped for export.
P Preliminary; - Nil.
Note: Numbers may not add to totals due to rounding.

TABLE 2. WORLD PRODUCTION OF PLATINUM GROUP METALS, 1984-87

	1984	1985	1986	1987
		(tonnes)		
EUROPE				
Finland				
Palladium	34	35	96	90e
Platinum	33	35	120	120e
Yugoslavia[e]				
Palladium	96	103	96	96
Platinum	6	8	8	8
Subtotal	169	181	320	314
AFRICA				
Ethiopia[e]				
Placer platinum	4	5	5	5
South Africa				
Platinum group metals	108 862	115 000	123 000	131 000
Zimbabwe				
Palladium	38	30	35	36
Platinum	24	19	26	26
Subtotal	108 928	115 054	123 066	131 067
ASIA				
Japan				
Palladium	1 051	1 359	1 453	1 417
Platinum	607	691	663	753
Subtotal	1 658	2 050	2 116	2 170
AMERICA				
Canada				
Platinum group metals	10 369	10 534	12 190	10 930
Colombia				
Placer platinum	314	362	447	470
United States				
Placer platinum and platinum group metals	455	w	w	w
Subtotal	11 138	10 896	12 637	11 400
AUSTRALIA				
Palladium	523	476	428	491
Platinum	66	95	115	131
Subtotal	589	571	543	622
EASTERN COUNTRIES				
U.S.S.R.[e]				
Placer platinum and platinum group metals	115 000	118 000	120 000	121 000
WORLD TOTAL	**237 482**	**246 752**	**258 682**	**267 573**

Source: Energy, Mines and Resources Canada.
[e] Estimate; w Witheld to avoid disclosing company proprietary data; excluded from "Total";

TABLE 3. PLATINUM SUPPLY AND DEMAND, WESTERN WORLD, 1981 AND 1987

	1981	1987
	(000 grams)	
Supply		
South Africa	55 986	78 381
Canada	4 043	4 354
Others	933	1 244
	60 963	83 979
U.S.S.R. sales	11 508	12 441
Total	72 471	96 421
Demand		
Western Europe	13 063	17 418
Japan	35 769	51 321
North America	21 772	27 993
Rest of western world	4 977	5 599
	75 581	102 330
Western sales to COMECON/China	933	933
Movements in stocks	(4 043)	(6 843)
Total	72 471	96 421

Source: Johnson Matthey Public Limited Company.
( ) Brackets refer to reduction.
Note: Data converted from ounces; totals may not add due to rounding.

TABLE 4. PALLADIUM SUPPLY AND DEMAND, WESTERN WORLD, 1981 AND 1987

	1981	1987
	(000 grams)	
Supply		
South Africa	28 304	33 903
Canada	4 977	5 910
Others	2 177	2 799
	35 458	42 612
U.S.S.R. sales	44 478	55 675
Total	79 936	98 287
Demand		
Western Europe	9 331	17 262
Japan	25 505	44 167
North America	25 505	32 970
Rest of western world	4 666	5 443
	65 006	99 842
Movements in stocks	14 930	(1 555)
Total	79 936	98 287

Source: Johnson Matthey Public Limited Company.
( ) Brackets refer to reduction.
Note: Data converted from ounces; totals may not add due to rounding.

TABLE 5. PLATINUM CONSUMPTION BY APPLICATION, 1981 AND 1987

	1981	1987
	(000 grams)	
Western world		
Auto catalyst (net)	19 906	35 458
Chemical	7 776	6 065
Electrical	5 754	5 599
Glass	3 110	3 732
Investment	6 065	15 241
Jewellery	23 483	30 792
Petroleum Refining	4 354	1 711
Other	5 132	3 732
Total	75 581	102 330
Japan		
Auto catalyst (net)	5 910	9 176
Chemical	311	467
Electrical	467	1 400
Glass	1 555	1 400
Investment	6 065	10 420
Jewellery	19 440	27 993
Petroleum Refining	467	-
Other	1 555	467
Total	35 769	51 321
North America		
Auto catalyst (net)	13 374	18 351
Chemical	1 555	1 711
Electrical	2 177	2 022
Glass	622	778
Investment	-	2 644
Jewellery	467	467
Petroleum Refining	1 711	467
Other	1 866	1 555
Total	21 772	27 993
Rest of western world including Europe		
Auto catalyst (net)	622	7 931
Chemical	5 910	3 888
Electrical	3 110	2 177
Glass	933	1 555
Investment	-	2 177
Jewellery	3 577	2 333
Petroleum Refining	2 177	1 244
Other	1 711	1 711
Total	18 040	23 017

Source: Johnson Matthey Public Limited Company.
- Nil or not separetely available.
Note: Data converted from ounces; totals may not add due to rounding.

TABLE 6. PALLADIUM CONSUMPTION BY APPLICATION, 1981 AND 1987

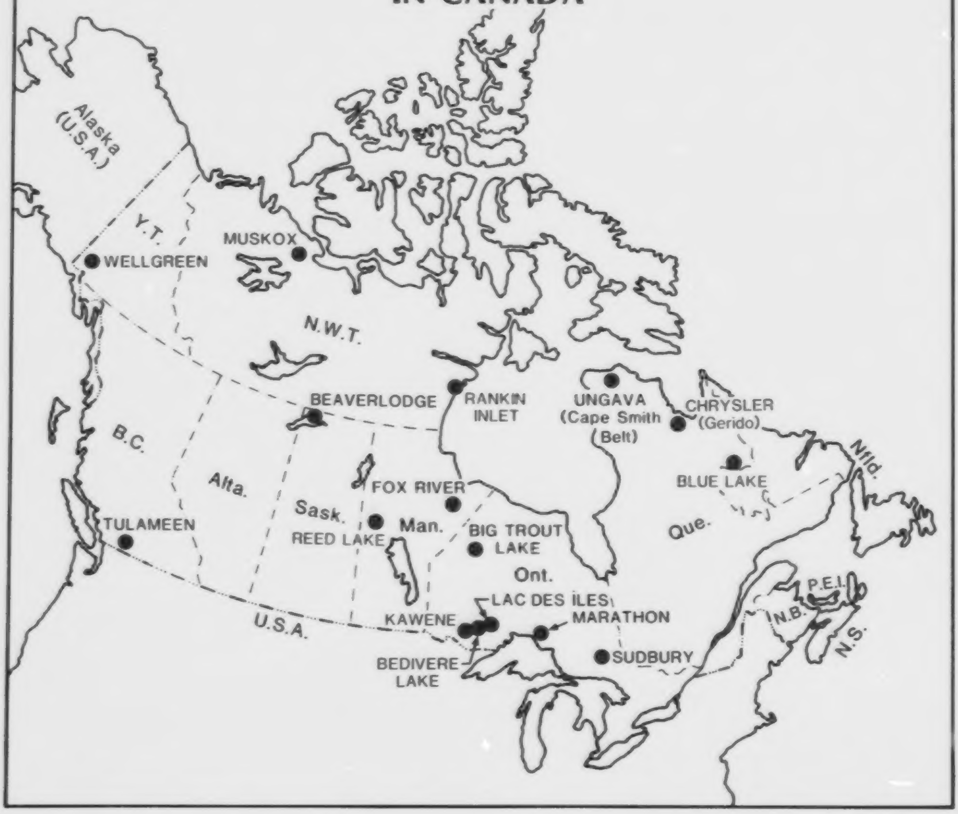
	1981	1987
	(000 grams)	
Western world		
Auto catalysts	8 398	6 376
Dental	14 930	30 948
Electrical	24 883	50 232
Jewellery	6 532	5 132
Other	10 264	8 398
Total	65 006	101 086
Japan		
Auto catalysts	4 354	2 022
Dental	4 977	9 020
Electrical	11 197	28 771
Jewellery	1 866	2 488
Other	3 110	1 866
Total	25 505	44 167
North America		
Auto catalysts	4 043	3 732
Dental	6 532	13 374
Electrical	10 264	13 219
Jewellery	311	311
Other	4 354	3 577
Total	25 505	34 214
Rest of western world including Europe		
Auto catalysts	-	622
Dental	3 421	8 553
Electrical	3 421	8 242
Jewellery	4 354	2 333
Other	2 799	2 955
Total	13 997	22 706

Source: Johnson Matthey Public Limited Company.
- Nil.
Note: Data converted from ounces; totals may not add due to rounding.

TABLE 7. AVERAGE PRICES FOR PLATINUM AND PALLADIUM

		Platinum		Palladium	
		NY Dealer	London	NY Dealer	London
		(US$/oz.)			
1988	December	567.38	569.82	131.14	131.95
	November	566.50	575.80	125.48	126.28
	October	522.10	526.37	120.68	121.86
	September	506.24	512.29	119.62	120.57
	August	529.13	532.75	122.96	123.71
	July	543.25	548.64	124.45	125.89
	June	576.36	579.63	127.46	128.03
	May	544.52	548.94	122.10	123.41
	April	523.33	526.56	121.50	123.00
	March	491.17	496.39	121.44	122.17
	February	451.85	458.51	118.90	119.72
	January	491.58	493.63	123.66	124.49
1987	December	499.50	500.65	120.59	120.30
	November	494.21	500.30	111.21	113.78
	October	564.48	567.67	129.24	131.15
	September	586.33	590.00	136.71	137.24
	August	608.33	610.52	140.00	141.11
	July	568.30	572.32	139.50	141.05
	June	565.27	569.00	136.71	139.02
	May	569.00	606.15	144.70	147.28
	April	584.50	585.59	135.93	137.67
	March	525.23	532.64	122.50	124.17
	February	514.63	517.76	119.50	120.60
	January	515.00	518.86	122.75	123.41
1986	Average	461.59	464.92	115.96	117.00
1985	Average	291.47	n.a.	105.76	n.a.
1984	Average	356.82	n.a.	148.18	n.a.
1983	Average	423.53	n.a.	136.16	n.a.
1982	Average	327.02	n.a.	66.83	n.a.
1981	Average	445.99	n.a.	94.58	n.a.
1980	Average	677.31	n.a.	200.78	n.a.
1979	Average	444.60	n.a.	119.56	n.a.
1978	Average	260.77	n.a.	63.02	n.a.

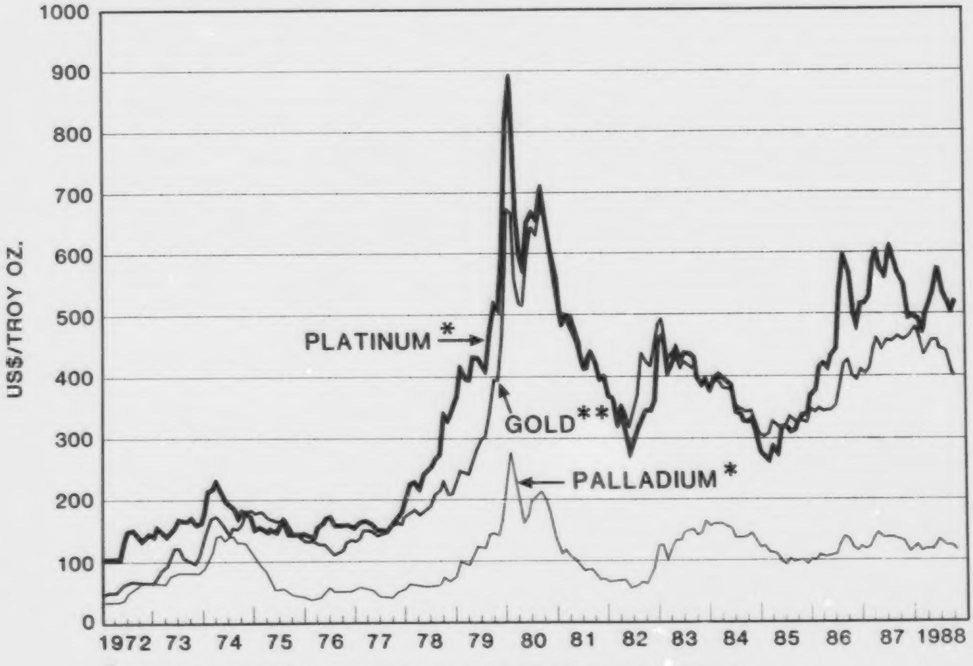
Source: Metals Week.
n.a. Not available.



SELECTED PLATINUM GROUP METAL OCCURENCES IN CANADA

Alaska (U.S.A.)
Y.T.
WELLGREEN
MUSKOX
N.W.T.
BEAVERLODGE
RANKIN INLET
UNGAVA (Cape Smith Belt)
CHRYSLER (Gerido)
Nfld.
B.C.
Alta.
Sask.
FOX RIVER
BLUE LAKE
Man.
REED LAKE
BIG TROUT LAKE
Que.
TULAMEEN
Ont.
LAC DES ILES
MARATHON
KAWENE
P.E.I.
N.B.
N.S.
U.S.A.
SUDBURY
BEDIVERE LAKE

PRECIOUS METAL PRICES
1972-88



* AVERAGE MONTHLY NEW YORK DEALER PRICE (METALS WEEK)
** AVERAGE MONTHLY LONDON GOLD FIX

Potash

G.S. BARRY

SUMMARY

World production of potash in 1988 is estimated at 31.5 Mt K_2O equivalent, an increase of 1.8 Mt from 1987. This large increase is mainly attributed to higher production in the U.S.S.R. (+0.5 Mt) and North America (+1.0 Mt); all other producers operated at levels just marginally higher than in 1987 (+0.3 Mt). Demand was slightly lower, resulting in an increase in inventories of between 0.4 to 0.5 Mt.

Production of potash in Canada in 1988 was estimated at 8.3 Mt, 14% higher than in 1987. Shipments from mines to customers and warehouses were also higher at 8.1 Mt, while estimated sales based on the data of the Potash and Phosphate Institute were between 7.9 and 8.0 Mt, some 1.5% higher than in 1987. Canadian producer stocks increased to 1.36 Mt, a level which could be considered normal at current monthly shipments and in view of the high demand anticipated in the 1989 spring season.

There was a rebound in potash consumption in 1988 in Canada and in all our major potash export markets including the United States. In the United States the acreage reduction program, which between 1984 and 1987 resulted in a 12% decline in planted acreage to 315 million acres, came to a halt. The planted acreage in 1988 was estimated at 319 million acres up 1%. The 1988 drought combined with strong world demand for cereals resulted in a drastic decline of world stocks to abnormally low levels. Projected increases in planted acreage in the United States for 1989 are in the 10% to 12% range, to above 350 million acres which may result in growth in potash demand in the United States of more than 0.6 Mt K_2O.

Potash prices recovered by more than 50% from the lowest levels of 1986. The f.o.b. Vancouver price, US$76-82/t at the beginning of 1988, rose steadily to US$90-95/t near the end of the year. Prices in the U.S. market remained strong and steady throughout 1988, at a level equivalent to just over US$90/t f.o.b. mine. These higher prices are required to comply with the suspension agreement with the United States that resulted from the settlement of the dumping case. However, offshore potash prices would have to increase by a further US$15 to $20/t before an equilibrium between North American and world prices is achieved. Throughout 1988 the higher U.S. prices attracted additional sales from offshore potash producers, particularly the U.S.S.R., which doubled its exports.

In 1988 the world potash supply/demand imbalance was still prevailing and overall capacity utilization was 84%, principally because Canadian mines operated at a low level of 73%, while almost all other world producers continued to operate at near optimum levels of capacity.

Canadian exports outside of North America, referred to as "offshore sales" in 1988, reached a record level estimated at 3.7 Mt, 20% over 1987. This performance was impressive especially after the increases of 19% and 35% over the previous two years. Asian markets were particularly strong but Canadian exports to the United States by contrast declined about 10% in 1988; however they are forecast to post an increase in 1989.

CANADIAN DEVELOPMENTS

The average value of potash shipped was $131.19/t K_2O (f.o.b. mines) in 1988 compared to $97.15 in 1987.

The average export value calculated by Statistics Canada, on the basis of port of exit (e.g. Vancouver or Saint John) or border crossing to the United States, was $184.76/t K_2O in 1988 (based on 10 months exports) compared to $146.46/t in 1987.

G.S. Barry is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 992-7568.

Over the years, there were significant variations in reported production and export statistics. Table 5 is a reconciliation of such data. Besides reported production variations, the data demonstrates that over a period of 17 years, exports were probably under-reported to Statistics Canada by almost 3.0 Mt.

The Canadian potash industry reported total net profits (before interest and after tax) of $49 million in 1987, after losses of $60 million in 1986 and $8 million in 1985. It is estimated that profits in 1988 will be in the order of $300 million (calculated on the same basis).

Employment in the Saskatchewan potash industry was estimated at 3370 in 1988 compared to 3580 in 1987. In New Brunswick employment in 1988 was estimated at 874 compared to 854 in 1987.

For short intermittent periods in the summer and fall, all conventional potash mines in Saskatchewan closed for maintenance, vacation, and on a limited lay-off basis. Winter closures for inventory control, common in the past, were almost completely omitted in 1988.

The Potash Corporation of Saskatchewan (PCS) partially closed the Cory mine for an indefinite period effective July 15, 1988, laying off about 200 employees.

Preliminary Principal Statistics for 1987 are now available. They indicate that 34 436 000 t of ore were milled to produce 7 398 700 t of K_2O (12 117 000 t KCl). The average recovered grade was 21.5% K_2O. The recovery of potash from ore was approximately 88%. Ore grades range from 23% to 26% K_2O. One mine is an exception, where the mining practice is to mine two potash beds with the intervening waste which results in lower ore grades. By contrast mines in the U.S.S.R., the world's largest potash producer, extracted between 80 and 85 Mt of ore to produce 10.5 Mt K_2O for an average recovered grade of 12% to 13% K_2O.

Canadian mine production revenue was approximately $756 million in 1987. The cost of all direct inputs was $203 million. The "value added" was therefore $553 million, compared to a record of $899 million established in 1981. Approximately 48% of the total costs were for energy. The industry employed 4124 persons in 1986 with salaries and wages of $146 million. The average wage per employee was $35 470 in 1986. A total of 3076 persons were employed directly in mining and milling. Productivity per worker per year was 2 405 t K_2O in 1987, which is 2 to 5 times higher than in any other producing country. For example annual productivity is 400 t K_2O per worker in the U.S.S.R., 700 t in the United States and 1100 t in Israel, which is considered the second most efficient potash producer after Canada. It is important to note that because of low capacity utilization in Canada in 1987 the productivity of 2405 t per worker is lower than the norm.

On February 10, 1987, two U.S. potash producers, Lundberg Industries Inc. and New Mexico Potash Corp. filed an anti-dumping petition against Canadian potash producers.

A preliminary determination, by the United States International Trade Commission (ITC), handed down on March 23, determined that imports of Canadian potash had caused material injury to the U.S. potash industry. The United States Department of Commerce (DOC) determined on August 20, also on a preliminary basis, that Canadian potash had been sold at less than "fair value" in the United States. The DOC then imposed antidumping duties against all Canadian potash producers ranging from 9.41% to 85.2%.

Successful negotiations took place in December and a suspension agreement between DOC and all the Canadian producers was signed on January 8, 1988. In entering into this agreement, the Canadian producers did not admit that any exports of potash from Canada have had an injurious effect on U.S. producers, but they did agree to follow pricing practices, under specific formulas, that could not be construed as dumping. DOC will monitor Canadian exports until January 1993 after which this trade dispute will be terminated.

In response to general market conditions and the U.S. action the Saskatchewan government introduced legislation in September 1987 giving the province the right to control the aggregate level of potash produced in Saskatchewan, to allocate quotas to the various producers and to control any future expansion of potash production capacity. Saskatchewan has not yet implemented its legislation but the government now has powers that could be swiftly invoked should the potash market situation justify it.

At the end of 1988, Canadian installed potash production capacity was 10 270 000 t K_2O in Saskatchewan and 1 160 000 t K_2O in New Brunswick for a total of 11 430 000 t K_2O (19 050 000 t KCl). The largest share of Canadian capacity, 45.8%, is held by Potash Corporation of Saskatchewan (PCS), a provincial Crown corporation, followed by International Minerals & Chemical Corporation (IMC) with 15.3%, the largest private producer in the western world. In 1987, 630 000 t of capacity in Saskatchewan was lost through flooding, but it will be replaced partially by extracting potash using solution technology.

SASKATCHEWAN

The Potash Corporation of Saskatchewan (PCS) made a dramatic comeback to profitability during 1988, with net profit surpassing $100 million after a $20.7 million loss in 1987 and a $103.4 million loss in 1986.

In 1987 the provincial government decided to transfer $662 million of PCS debt to the Crown Investment Corporation (CIC), converting it to equity. This raised the total government equity in PCS to $1.142 billion. The company was left with $138 million in long-term and short-term debt. It is surmised that PCS will be in a position to pay a dividend in 1988 to the Crown Management Board to offset a large part of the interest charges on the debt write-off as well as cover some of its short-term debt obligations.

The five divisions of Potash Corporation of Saskatchewan Mining Limited (PCS Mining) produced just over 5.0 Mt of potash (KCl) in 1988 compared to 4.3 Mt in 1987 and only 3.6 Mt in 1986. Early in 1988 PCS said that productivity increased by 15% to 20% at each of its five mines. Nevertheless, after Lanigan's completion, the overall capacity utilization was less than 60% and the company had to find a solution to this low utilization as unit costs of production were prohibitively high. Management decided to continue the operation of two mines on a five-day per week basis and one on a seven-day per week basis, to mothball the older of the two Lanigan refineries and to close some 80% of production capacity at the Cory mine. This procedure resulted in a temporary withdrawal of about 1 350 000 t K_2O of nominal capacity. Based on the 1988 production estimate, PCS achieved a 78% capacity utilization of the remaining active capacity. The concentration of production in the lowest cost mines not only significantly contributed to the company's profitability but obviated the need of more lengthy intermittent closures at all the mines. The unavoidable casualty was 200 jobs lost at Cory. It is currently assumed that it will take another three to four years before PCS Mining can return to full employment at all of its mines.

PCS continued to trim employment, which is estimated at about 1276 at the end of 1988, down from 1480 in 1987 and 1668 in 1986. The company continued its policy of closing all its mines for a four week vacation and maintenance in July and August. A December shutdown for inventory control, a common practice for the past few years, was minimized just to a three-day closure for statutory holidays, partially because there was a need to increase stocks in anticipation of a very strong spring season in 1989.

The new mill at the Lanigan mine completed in 1987 is performing well, while the older mill was temporarily mothballed except for the compaction section which processes the product from the new installation. Nominal capacity at Lanigan was now raised to 2 090 000 t K_2O of which about 700 000 t is idle. Employment at the end of 1988 was 318.

The Cory mine was partially closed in July with the loss of 200 employees. The mine will operate with one continuous miner, providing enough ore to produce through its crystallizer unit up to 200 000 t of white, high grade product (62.4% K_2O) per year. The potassium sulphate plant was also closed. Employment at year-end was 110 compared to 315 the previous year.

PCS's 10 tonnes per day (t/d) industrial grade potassium sulphate plant at Big Quill Lake, brought on-stream in July 1987, continued operations. It produces good quality product but as yet has not reached capacity, operating only at about 6.5 t/d.

The Esterhazy Division of PCS Mining, experienced major costs related to flooding problems at the IMC K2 mine, since PCS is responsible for 25% of such costs. Output from this mine, on account of PCS, was near capacity levels.

The Allan mine continued to operate in 1988 at reduced capacity levels. Output on account of Saskterra Fertilizers Ltd. was more than its proportionate share of the mine. Employment at Allan was 329.

The Rocanville mine operated near optimum capacity levels (exceeding 90%) on a seven-day per week basis. This operation is considered as the lowest-cost mine in Saskatchewan and probably the world. Employment at Rocanville was 358.

Some three years ago, the Government of Saskatchewan announced its intention to privatize PCS when conditions are right. Steps to privatize are likely to be taken in 1989 since the overall world potash markets, as well as PCS's performance, improved to the point where investment in potash becomes much more desirable.

Central Canada Potash (CCP), a division of Noranda Minerals Inc., a part of the Noranda Inc. group, produced 1 100 000 t of potash (KCl) in 1988 compared with only 877 000 t in 1987. CCP follows a policy of running the mine on a seven-day per week schedule while closing intermittently for inventory control. The company closed its Colonsay mine from December 20, 1987 to January 9, 1988; from July 10 to August 14 and from December 24 to January 2, 1989.

CCP has a particularly profitable second half of the year, when productivity increased substantially. CCP potash is sold on the offshore markets by Canpotex Limited, in North America by Noranda Sales Corporation Ltd. In the United States the principal customers are CF Industries, Inc. and Terra Chemicals International. Employment at year end was about 380 compared to 370 in 1987.

Cominco Ltd. produced 1 098 000 t of potash (KCl), in 1988 compared to 1 057 000 t in 1987. The company closed its Vanscoy mine from December 20, 1987 to January 3, 1988; from July 16 to August 14 and only for the statutory holidays in December 1988. While in operation, the Vanscoy mine is run on a seven-day per week basis to reduce unit production costs.

Flotation process improvements and direct purchase of natural gas from producers, as a result of natural gas deregulation, have contributed significantly to cost-control efforts. The productivity improvement program of 1988 also resulted in a further reduction of employment from 373 at the beginning of the year to 317 at year-end.

The International Minerals & Chemical Corporation (Canada) Limited (IMCC) wholly owned by IMC Fertilizer Group Inc. operates two mines near Esterhazy, Saskatchewan; K1 and K2 which are connected underground. In 1988, IMC Canada produced about 3.8 Mt KCl of which 25% was on PCS's account.

Employment at the Esterhazy operations was approximately 850 in 1988 compared to 810 at the end of 1987. Currently there is an additional 100 employed on water related problems. The mines were closed for only two weeks in July for vacation and maintenance. Better market conditions allowed the company to operate near optimum capacity utilization levels for most of 1988.

The K2 mine is still experiencing the water problems which started in December 1985. Chemical grouting, introduced in 1987 is ongoing and is the preferred method of keeping the water inflow at a level of between 1000 and 1500 gallons per minute. The pressure in the overlying water-bearing formation is kept at about 85% of normal formation pressures. Most of the water stored in the mine was pumped out and injected into deep wells. Since the remaining stored mine brines contain considerable potash, the company is currently experimenting with a winter pond settling system that would strip the excess potash (for a marketable product) before the brines are reinjected underground.

Litigation is still in progress over the insurance payments for the water inflow. Meanwhile, the present situation adds appreciably to the exploitation costs of potash at the IMC Canada mines.

In 1988, IMC Canada conducted a surface seismic exploration program covering the potash areas east and west of the mine, which will be followed by additional drilling in 1989 with the objective of keeping its options open on the eventual sinking of new shafts.

Kalium Chemicals operates a large solution mine at Belle Plaine, west of Regina. During 1988 the company produced almost 1.1 Mt K_2O about 10% above last years level.

An expansion program to a total capacity of 1.245 Mt K_2O was completed in 1987 but because of market constraints Kalium did not begin to utilize its full potential until the last quarter of 1988.

Kalium started disposal of waste salt in underground cavities in 1979; in 1987 the disposal rate increased to almost 100% of daily production. However, the company experienced some equipment problems in the injection system and had to substantially curtail the underground waste salt disposal during 1988. It is expected that these problems will be overcome during 1989.

In a potash solution mine, energy is the largest component of production costs. Natural gas deregulation in 1987 allowed Kalium (and other conventional mines) to buy 65% of their requirements on the open market and 35% from the Saskatchewan Power Corporation (SPC), and during 1988 all transactions shifted to the open market.

In 1988 the Kalium mine had approximately 318 employees, which included contract workers. In April 1988, the company moved its head office from the United States to Regina, Saskatchewan.

Potash Company of America (PCA), a Division of Rio Algom Limited closed its Patience Lake mine in February 1987 due to flooding. A study by Kilborn Engineering Limited completed in 1987 indicated that extraction of potash from the flooded mine could be commercially feasible through the application of novel solution mining techniques.

A successful pilot test was completed between September 1987 and May 1988 and a decision was made to invest $22 million on a facility that could produce about 700 000 t/y of product. The exact capacity will be determined only following the initial year of production.

The potash extraction scheme requires the drilling of intake/outlet wells to pump out potash-rich brine. The precipitation of potash in surface ponds follows the principles of natural preferential precipitation of KCl from a hot saturated brine as it is cooled in the winter environment (October-April). The 1988-89 program will consist of drilling eight large diameter outlet wells and a series of inlet wells located up dip in the potash formation of the flooded mine.

Approximately 125 acres of ponds will be prepared on the old tailings site. In April the retrieval of almost pure potash will begin by bucket wheel excavators for processing in the old PCA refinery. It is expected that some 250 000 t of product will be produced during the first year of operation. The plant will employ about 125.

Saskterra Fertilizers Ltd., a wholly owned subsidiary of Canterra Energy Ltd. of Calgary owns 40% of the Allan potash mine (60% PCS). In 1988 Saskterra's share of production amounted to about 500 000 t KCl.

In 1988 Saskterra continued to market its potash in the United States through International Commodities Export Corporation (ICEC). Its offshore tonnage was sold through Canpotex Limited until the end of 1987 and thereafter through ICEC.

Canterra Energy Ltd., the parent of Saskterra put the mine on sale in April 1988. The company however announced in August that it was not satisfied with the bids received and that the sale was deferred (until conditions for investment in potash improve markedly) on an indefinite basis.

MANITOBA

Canamax Resources Inc. and the Manitoba government formed Manitoba Potash Corporation (MPC) in which Canamax holds a 51% interest and the Manitoba government 49%.

MPC holds a potash deposit near Russell bordering on Saskatchewan, in which reserves of some 165 Mt grading 24.5% K_2O were outlined.

Kilborn Engineering Limited and Matrix Enterprises Ltd. completed an engineering and economic feasibility study in June 1987. The report proposed a 2.0 Mt/y KCl mine. Capital costs are estimated at $540 million in 1987 constant dollars. Direct operating costs were estimated at $26.26/t of product. Project economics were based on a f.o.b. mine price of $73/t. The projected permanent employment was 360, while during the peak construction year 700 would be employed.

The mine would have the advantage of a relatively shallow depth at between 850 and 900 m, about 100 m less than corresponding mines in Saskatchewan. The mining layout provides for especially designed access to each mining panel and isolation pillar barriers as a precaution against the risk of flooding.

MPC is currently trying to find partners with financial backing. Canadian and overseas producing companies and consumer groups were approached.

Late in the year the Manitoba Minister of Mines and Energy disclosed that Denison Mines Limited had a time-limited, exclusive option to make a development proposal but pulled out of the deal. There are reports that six other companies continue to be interested. The Minerals & Metals Trading Corp. of India Ltd. (MMTC), a large potash importer, is still reported to be interested in a minority participation in the future. MPC intends to renew its efforts to bring about a decision on the potash mine development in 1989. The provincial government would consider minority equity participation once private majority financing is assured.

NEW BRUNSWICK

The Potash Company of America (PCA) operates the Penobsquis mine situated 5 km east of Sussex, New Brunswick. The orebody at this mine is a steeply dipping deposit requiring mechanized cut and fill mining. The operators experienced protracted difficulties in achieving full capacity operations, mainly because the mine has a totally closed system, i.e. all waste salt and waste brines have to be returned underground. The new owner, Rio Algom Limited decided to spend $30 million to upgrade mining and processing and by the end of 1988 the Penobsquis mine essentially achieved its full capacity of 380 000 t/y K_2O. The shaft and some surface installations were designed to a capacity of 545 000 t/y K_2O, which will allow for a low unit cost expansion if the market improves in the 1990s.

Production at the Penobsquis mine exceeded 550 000 t KCl in 1988. Rock salt is produced as a by-product. The company had about 350 employees at year-end. The mine is operated on a seven-day per week basis, with a two week maintenance shutdown in July.

PCA exports practically all of its potash production through a new potash terminal located at Saint John, which it operates on behalf of the two New Brunswick producers. The terminal has a permanent employment of 8, but supports a total labor force of about 20 on an annual basis.

The Denison-Potacan Potash Company (DPPC) produced about 1 050 000 t of potash (KCl) at Cloverhill mine located 20 km southwest of Sussex, New Brunswick. The company made good progress to reach optimum capacity utilization and towards the end of 1988 operated consistently at near 90% of capacity. The installation of a $11 million crystallizer unit was completed in March and was fully operational in April 1988. Overall recovery rose to about 90% and product quality was improved. The product split is about 35% standard and 65% coarse and granular.

Because of the complexity of the orebody the company intends to continue extracting ore both by drill and blast methods and with continuous mining machines, which is carried out in a proportion of about 40 to 60.

Waste salt was returned to the mine since 1987. The backfill system still has some problems but progress is steady and currently slightly more than 50% of the surface flotation plant waste was being returned underground. The company plans to return 90% underground by the end of 1989 and waste salt stored on the surface in a tailings pond will be returned underground subsequently. Excess brine is dispatched by pipeline to the Bay of Fundy. Employment at the end of 1988 was 524. The mine was shut down for maintenance from July 1 to July 9, 1988. All of the potash output from the mine is marketed by Potash Company of Canada Limited (Potacan Limited) of Toronto, Ontario. Sales are approximately evenly split between North America and "offshore".

INTERNATIONAL DEVELOPMENT

Argentina - Yacimientos Petroliferos Fiscales (YPF) discovered a potash deposit while drilling for oil in the Province of Mendoza, Department of Malargue along Rio Colorado. The potash occurs in the saline Huitrin Formation, which lies at various depths between 750 and 1 200 m. The deposits were explored under concession by Duval Corporation and Minera TEA, a subsidiary of Texasgulf Inc. The U.S. companies hold no interest in the deposit. At present Minera TEA would like to find partners for further exploration and the eventual development of the deposit. Minera TEA reported that a selected bed of 2.2 m grades between 25% and 30% K_2O, with low insolubles. The formations are almost horizontal. The temperature of the formation is high (39°C to 53°C), rendering conventional mining of the deposit difficult. The company believes that there is a possibility of solution mining in an area where three potash beds coalesce to form a 9 m thick horizon grading between 20% and 25% K_2O. Infrastructure, rail or pipelines are required, the nearest railhead is 260 km from the deposit.

Argentina also has potassium bearing brines in the Salar de Hombre Muerto and the Salar del Rinson.

Bolivia - A state agency, Complejo Industrial de Recursos Evaporiticos del Salar de Uyuni (Ciresu) was formed to promote the exploitation of brine deposits in the Salar de Uyuni. These brines contain an average of 0.025% Li; 0.54% Mg; 0.62% K; and 9.10% Na. These concentrations are lower than those of the Salar de Atacama in Chile.

Brazil - PETROBRAS Mineracao S.A. (PETROMISA) officially opened the Taquari-Vassouras potash mine in the Sergipe District in March 1985. However as of the end of 1988, all the mining equipment was not yet in place and annual production was approaching 100 000 t KCl. PETROMISA estimated that it will take another two years to bring production up to designed capacity, but this optimism is not shared by all observers. The ore occurs in very small lenses that are difficult to locate. The company envisages that it may have to develop the Santa Rosa de Lima deposit located 16 km west of the mine to bring ore to the existing plant.

PETROMISA holds another interesting potash deposit near Fazendinha in the Amazonian basin. The deposit has an area extent of 130 km^2, an average thickness of 2.7 m and lies at a depth of 980 m to 1 140 m. Total reserves are estimated at 560 Mt grading about 27% KCl. In 1984, a $700 000 feasibility contract was awarded to a joint venture consisting of Paulo Abib Engenharia, Mines de Potasse d'Alsace and Patrick Harrison & Company Limited, a Canadian firm. Phase I of this study outlining development options was completed in September 1985 and Phase II comprising a more detailed engineering feasibility was started in 1986 and completed in 1987. PETROMISA stated that if the $1.0 billion, 1.5 Mt/y potash project is approved by the government, production could start in 8 to 10 years.

PETROMISA forecast Brazilian potash consumption to reach 2 150 000 t KCl in 1990.

Chile - AMAX Exploration, Inc. jointly with Molibdenos y Metales S.A. (Molymet) were awarded the rights by Corporación de Fomento de la Producción (CORFO) to develop the potash-lithium-boric acid deposits of the Salar de Atacama. Sociedad Mineral Salar de Atacama Ltda (MINSAL Ltda) was formed in 1986 with the following equity distribution: AMAX 63.75%, CORFO 25% and Molymet 11.25%.

The Atacama brines contain in average 0.125% Li, 0.91% Mg, 1.87% K, and 6.92% Na. Field tests and feasibility studies will be completed in 1989 and if successful may lead to full production by the 1992/94 period.

Initially, the target size of the project was 500 000 t/y KCl, 200 000 t/y K_2SO_4, 30 000 t/y of boric acid and an undetermined amount of lithium chemicals. More recently, AMAX stated that annual production could be up to 650 000 t of KCl equivalent. Initially, there would be a cap on lithium metal production of 2 800 t/y with a provision for annual increases of 7%. Permission to extract lithium, which is in oversupply, was crucial since without it the economic exploitation of the brines would not have been possible. MINSAL estimated that the brine deposit reserves consist of 46.7 Mt KCl and 21.2 Mt sulphate.

A full feasibility study by Jacobs Engineering Group Inc. will be completed in January 1989. By approximately March the company may be in a position to make a final production decision. Assuming that construction would start in the fall of 1989, first production could be expected in 1992 with full capacity achieved by 1994/95. The initial production life will be 26 years.

Sociedad Chilena de Litio Ltda (SCL) started production of potassium chloride in November 1988 at an annual capacity of 20 000 t K_2O equivalent. The product will be shipped to the Soquimich KNO_3 plant at Maria Elena to supplement KCl now imported mainly from Canada.

China - A small potash plant, serving local markets, exists at the eastern part of a dry lake, Lake Qarhan (Chaerhan) in the Qinghai province. Output is about 40 000 t/y KCl of low-grade product grading between 45 and 50% K_2O. Brines are pumped into solar ponds from trenches dug into the dry salt lake surface. Concentrated salts from the solar ponds are subject to rough flotation producing the low-grade product. Currently, construction is well advanced on additional solar ponds that will provide the raw material for a nearby plant of 200 000 t/y KCl capacity to be completed by 1990. Capital costs are estimated at 400 million yuan (US$108 million).

The authorities of the Quinghai province are also interested in contracting a feasibility study on a 800 000 t/y KCl plant for the west end of Lake Qarhan to be based on western technology that would yield a high-grade product for markets outside western China. Such a plant would require $500 to $600 million in investment and is not likely to be completed earlier than in mid- to late 1990s.

Congo (People's Republic) - Entreprise minière et chimique (EMC) signed a joint venture agreement with the Congolese government to establish the feasibility of mining potash again at Holle, near Pointe Noire. A feasibility study was completed. Mining was carried out there from 1969 to 1977 when the mine was flooded. The press reported that the resumption of output at Holle must be considered to be realistic perhaps after 2000. Solution mining could be an alternative to a conventional mine.

France - Production by the Mines de Potasse d'Alsace (MPDA) in 1988 was approximately 35 000 t K_2O less than in 1987, principally in response to lower domestic consumption, and higher imports. The Theodore mine was closed in March 1986, and a second mine will be closed in four to five years resulting in a further decrease of French capacity.

MPDA brings to the surface approximately 6 Mt of waste salt. Less than 10% can be sold commercially and the rest must be disposed of on the surface since a return of the moist residue to the mine is technically impossible. Over the years MPDA disposed of most of the brines into the Rhine. Studies show that MPDA is responsible for approximately 36% of the chlorine ions injected into the Rhine. Nevertheless, as the most visible polluter MPDA was singled out for much of the problem. In 1983, France ratified the Bonn Convention (of 1976) and thus took on the responsibility to decrease the flow of brine into the Rhine. MPDA, which near the end of 1986, rejected between 110 and 115 kg per second of chlorine ions, started a reduction program of 20 kg/s on January 1, 1987 and has the intention to cut another 40 kg/s starting January, 1989. This program will reduce chlorine rejected to the Rhine to about 50 kg/s and will make MPDA responsible for only 20% to 23% of the total rejects into the Rhine. The salt is stockpiled at mine site on a temporary basis at a rate that corresponds to 750 000 t/y (equivalent to 15 kg/s). The future disposition of the stockpiled waste salt is not yet determined. Studies and experiments with deep well injection have been completed but not accepted by environmentalists and the local population. Transport to the sea is prohibitively expensive. It has been suggested that a slow disposal back into the Rhine may be permitted once the MPDA mines cease production after the year 2000.

German Democratic Republic (GDR) - Production, from ten mines in the GDR for the past few years, has been more or less steady. In 1987, GDR produced 3 510 000 t K_2O and in 1988 production was estimated at 3 510 000 t K_2O. Production in 1989 is expected to remain at the same level.

GDR, through its marketing agency Kali-Bergbau, exported approximately 2.82 Mt K_2O of which about 55% was to market-economy countries and China, and 45% to COMECON countries including Cuba.

Germany, Federal Republic of (FRG) - Kali und Salz AG (K + S) is the sole producer of potash in FRG. Production in 1988 was estimated at 2.28 Mt K_2O, compared to 2.2 Mt in 1987. FRG is the major exporter of potash in the EEC, but 60% of its exports are intra-western Europe.

K + S rationalized its potash capacity in 1987 reducing it to 2.7 Mt K_2O. The combined capacity at the four mines in Lower Saxony is now 1.1 Mt/y K_2O and at the three Hessen mines is 1.6 Mt/y.

Israel - The Dead Sea Works Ltd. (DSW) potash plant at Sdom has a capacity of 2.1 Mt/y KCl. An additional capacity of 200 000 t/y will be added by 1990. In 1988 production was 2 070 531 t KCl. The expansion work involves the debottlenecking of the hot crystallization plant, modifications to the cold crystallization plant and to the solar ponds by switching a salt pond to carnallite precipitation, which became technically feasible because of the rising salinity of the Dead Sea. Further capacity additions are possible in the future if new ponds are added. There is a limitation, however, on the available land area for pond construction and DSW is currently conducting tests to determine if the newly exposed seabed area is suitable for this purpose. The 250 000 t/y KCl flotation plant closed since April 1985 is held on maintenance with a view to possible reactivation. Total employment is 1155.

A transportation system, including an 18 km conveyor belt from Sdom to a new rail terminal at Tsefa which eliminated costly truck haulage was commissioned in March 1987 (the elevation difference is 800 m), is working well.

In late 1987 investment commenced in a semi-industrial pilot plant for the manufacture of potassium sulphate from gypsum.

Haifa Chemicals Ltd., recently expanded its potassium nitrate capacity from 200 000 t/y to 250 000 t/y KNO_3.

Italy - Societa Italiana Sali Alcalini SpA (Italkali), a government controlled company, produces potassium sulphates from two Sicilian mine groups which together have reserves of more than 150 Mt of kainitic ores (10 to 12% K_2O). Realmonte produces about 400 000 t/y of kainite ore and Pasquasia about 0.9 Mt. Two refineries at Casteltermini and Pasquasia had an originally designed capacity of 170 000 t/y and 230 000 t/y of potassium sulphate, but were never capable of producing at that level. Modernization of the Pasquasia mine-mill complex was completed in 1988. It will take up to 1990 to bring the Casteltermini plant (also known as Campofranco) to design capacity. Potash production is expected to rise to just over 150 000 t K_2O equivalent in 1989.

Jordan - The Arab Potash Co. Ltd. (APC) made steady progress toward full capacity utilization of its Dead Sea potash plant at Ghor-al-Safi. Production in 1988 was estimated at 785 800 t K_2O compared to 722 000 t in 1987. The plant operated efficiently, increasing production despite the necessity of introducing intermittent closures to integrate the expansion project. APC selected the Finnish company, Yleinen Insinooritoimisto (YIT), to carry out an US$11.7 million expansion and modification of the potash refinery. This 15 month project was completed on schedule in March 1988. It raises APC's productive capacity to above 840 000 t/y K_2O.

APC undertook dredging work to deepen the existing Dead Sea brine intake channel and to increase the capacity of the intake pumps. The work is expected to be completed in March 1989. During the past five years the Dead Sea level has been falling faster than originally anticipated.

APC with the aid of the World Bank started pilot plant experiments with the energy saving, cold leach potash crystallization process. If successful, this technology would allow APC to undertake a further stage No. 1 expansion of about 240 000 t/y K_2O during the early 1990s. This could be followed by another addition of similar magnitude in later years.

South Korea - Kyunggi Chemical Corp. completed the expansion of their potassium sulphate plant from 40 000 t/y to 80 000 t/y.

Spain - The Spanish potash industry produced approximately 765 000 t K_2O in 1988 compared to 745 000 t in 1987.

Potasas de Subiza, (POTUSA) owned 50% by Instituto Nacional de Industria (INI) and 50% by the local government, El Gobierno Foral de Navarra, successfully completed the second full year of production. Ore reserves are limited but will allow for the operation of the Subiza mine to the mid-1990s. Thereafter, a second deposit, Los Pintos, 40 km from Subiza could be developed for production. The press reported that the government of Navarra intends to sell its equity in POTUSA. In the future, potash mining in Spain will be concentrated in the Catalonia District where capacity at the Suria mine will be expanded. There is also a possibility of opening a new mine between Suria and Llobregat in the more distant future. There is some uncertainty as to whether the Cordona mine can remain in operation in the 1990s, unless major exploration efforts are successful.

Explosivos Rio Tinto S.A. (ERT) controls the Cordona and the Llobregat mines of Catalonia. Since 1987, the Kuwaiti interests control 25% of ERT. In 1988 S.A. Gros and ERT merged to form a new company, Ercros.

Sweden - Boliden Kemi AB intends to start production of potassium sulphate at its Helsingborg plant, which until recently produced only sodium sulphate. Production may be up to 50 000 t/y of product. Domestic consumption is about 30 000 t/y.

Thailand - Thailand has two potash bearing saline basins, the Khorat (33 000 km^2) and the Sakhon-Nakhon basins (17 000 km^2). The Department of Mineral Resources (DMR) started a pilot project in 1982 to demonstrate the feasibility of carnallite exploitation near Chaiyaphum in the Khorat basin. An inclined access drift was sunk but had to be abandoned because of high water inflow in 1983.

In 1984 two potash concessions were awarded: one to Thai Potash Co. Ltd. (CRA Limited - Duval Corporation - Siam Cement Co.) on 3 500 km^2 and the other to Thai Agrico Potash Co. Ltd. (Agrico Chemical Co. - Thai Central Chemical) on 2 333 km^2. Each company was committed to spend a total of US$3 million on exploration over a five-year period. Agrico was reported to have relinquished the concession. Additional drilling was encouraging, but much artesian water was encountered. The concessioners are presently looking for additional partners. The Thai deposits present a geological challenge since the disposition of secondary sylvinitic ore is discontinuous in predominantly carnallitic potash formations.

Tunisia - As reported in 1986, an initial feasibility study was completed on the possibility of extracting potassium and other salts from the Zarzis brines by French companies. Société de développement des Industries chimiques du Sud (S.D.I.C.S.) was reported to be looking for companies interested in pursuing further research and development. Apparently a 120 000 t/y K_2O potassium sulphate plant would be a part of the development plan.

During 1988 a search for foreign development capital was unsuccessful, and the project was apparently deferred until the 1990s.

United Kingdom - Cleveland Potash Ltd. (CPL) had an exceptionally good year and produced an estimated 470 000 t K_2O in 1988. The company completed the installation of a pilot facility to recover potash from brines in 1986. The unit continues to work well and above originally designed capacity.

During 1988 CPL increased the capacity of its flotation cells and improved recovery. The company also bought a new Jeffrey heliminer.

The company is steadily gaining experience in mining in difficult ground conditions and is expected to further increase output in 1989.

United States - Production in 1988 was estimated at about 1 380 000 t K_2O, about 120 000 t above the 1987 level. Production is expected to show a further improvement in 1989 but will probably start to decline thereafter.

Total U.S. nominal potash capacity currently a 1 500 000 t/y K_2O is likely to rise to about 1 700 000 t/y as Mississippi Chemical Corporation resumes production. By the mid-1990s however, two mines in the Carlsbad area may close due to ore exhaustion. A positive supply-demand picture may induce Kalium Chemicals to start solution mining in Michigan by 1994 or shortly thereafter.

Great Salt Lake Minerals & Chemicals Corporation (GSL) ceased operations at its Utah plant in 1984 when Great Salt Lake rose to abnormally high levels and evaporation ponds were flooded. The company started pumping operations in April 1987 which will last three to four years. Initial production will start in 1989 but it would take a further three to four years to reach full capacity of 218 000 t/y K_2SO_4.

Kaiser Brine Chemical Inc. which operates the Wendover, Utah potash plant has been purchased by Reilly Tar and Chemical Corp. and renamed Reilly Wendover Chemical Inc. During 1988 the plant operated at near capacity levels of 58 000 t/y K_2O.

AMAX Chemical Corporation reopened its Carlsbad, New Mexico mine on March 30, 1986. The mine was closed since October 5, 1985. The company will terminate mining the remaining ore on the No. 1 zone by February 1989 and will concentrate on mining the lower grade and thin (1.2 m) No. 3 zone, on an indefinite basis. Thus, the permanent closure of the AMAX mine originally expected in early 1989 has been obviated by the quick rise of potash prices.

Texasgulf Inc. operates a solution and solar evaporation mine in Moab, Utah. Production of potash was expected to end in 1988 but because of good markets for the by-product common salt, it was decided to keep potash production on an indefinite basis at about half the original installed capacity of 110 000 t/y. The company is also examining the possibility of expanding solution mining in the future to areas outside the flooded conventional mine from which the potash now originates.

Lundberg Industries Inc. which operated the former PCA mine at Carlsbad, New Mexico, since March 1986, went into receivership and was sold to Trans-Resources Inc., for US$5 million cash and US$7 million in deferred payments. The new owners took control on June 28, 1988 and renamed the operation Eddy Potash Co. The mine has sufficient ore reserves to operate into the mid-1990s.

New Mexico Potash Corp. operates the former Kerr-McGee mine at Hobbs, New Mexico. The company is controlled by Cedar Chemical Inc., the same group that controls Trans-Resources Inc. The plant capacity was rationalized to just slightly above half the former rate of 300 000 t/y. The company produces essentially high grade potash (62.2% and 62.4% K_2O) but is selling about half of its output on the fertilizer markets. During 1989, marketing of products from both the Eddy Potash and the New Mexico Potash mines will be consolidated under one group.

Western Ag-Minerals Co. produces potassium sulphates at its Carlsbad, New Mexico plant. The company operated below optimum capacity in 1988. Markets for its sulphate products are expected to further improve in 1989. Western Ag is 35% owned by a Canadian company, Rayrock Yellowknife Resources Inc. The langbenite ore is produced at the Nash Draw mine and then transported by a circuitous, 105 km by rail haul to the Saunders surface plant (former mine) which is located only 23 km to the north.

International Minerals & Chemical Corporation (IMC) is one of the oldest and most versatile Carlsbad producers. The company mines sylvinite and mixed sylvinite and langbenite ores thus producing chloride and sulphate products. The company operated throughout 1988 at near full capacity levels.

Mississippi Chemical Corporation announced in May 1988 that it will re-open its potash facilities closed since January 1983. The company intends to start mining at a rate of 300 000 s.t./y of product (163 300 t K_2O) by early 1989. The former capacity was 400 000 s.t./y (217 700 t K_2O). Reserves are sufficient for many years of operation. Ore will be extracted from the Seventh Ore Zone (50 to 74 in. thick) grading about 15% K_2O and the Fifth Ore Zone only 36 to 48 in. thick grading 20% K_2O. The ore will be processed on site, and up to 135 000 t/y of product will be transported to the old National Potash surface plant for compaction and storage. This mine has the potential of further capacity increases in the future.

Kalium Chemicals holds rights to a deep-seated potash deposit near Hersey, Michigan. The company completed some initial solution mining tests in 1985 and 1986. The company recently announced that it will construct a small tonnage pilot plant to be completed by the end of 1989. The objective is to fully assess the commercial viability of the Hersey deposit.

U.S.S.R. - The U.S.S.R. is the world's leading producer of potash and the second largest exporter after Canada. In 1987, the U.S.S.R. exported 3 208 000 t of which 39% was to market-economy countries and China and 61% to COMECON countries, including Cuba, North Korea and Vietnam. Exports increased by 6.4% between 1986 and 1987. It is estimated that total exports increased in 1988 to almost 3.4 million K_2O of which about 1.4 million was destined outside the COMECON countries.

Progress was made in increasing the efficiency of the existing potash mines in the U.S.S.R., following the 1986 flooding of the Berezniki 3 mine. It is understood that the mine is no longer in operation but that the surface facilities are utilized to process ores from the adjoining mines. A new mine, Berezniki 4 was reported to have started production in early 1988. The plant will operate with Lurgi crystallizers. Lurgi GmbH, reported that the construction of the crystallizers is behind schedule and the plant should start in 1989. Soviet authorities reported that Berezniki 4 will have a final capacity of 1.6 Mt/y of K_2O. The two Lurgi units only have a capacity of 625 000 t/y each so the difference is hard to account for.

The Novosolikamsk mine currently operates at a capacity of about 1.0 Mt and is still under expansion to approximately 1.2 Mt/y K_2O in the early 1990s. Research facilities at the Karlyuk potash brines operation are already in place and small quantities of potash were produced. It is surmised that a larger commercial plant will not be completed and effectively operational before the early 1990s.

Total potash productive capacity in the U.S.S.R. was estimated at between 10.5 and 10.7 Mt K_2O in 1987, but production was recently reported at 10 889 000 t K_2O. It is clear that either the capacity was seriously underestimated or actual production and Soviet consumption have been overestimated.

The U.S.S.R. is putting more emphasis on agriculture and domestic fertilizer consumption; in the potash sector the rate of growth in consumption between 1988 and 1995 may exceed the growth in production.

PRICES

Typical contract prices for Canadian potash (standard grade KCl) moving out of Vancouver, which were in the range of US$76-82/t at year end 1987, moved up steadily to end 1988 at US$90-95/t. Two years ago prices were in the low 50's. By historical standards potash export prices are still substantially lower than levels achieved in 1980 and 1981. Export prices are also currently low in comparison to the "domestic" prices quoted in the U.S. markets. The price gap between the two markets is in the order of $20/t.

Prices for delivery in Canada were steady throughout the year. Granular grade was quoted at C$123/t f.o.b. mine in January with a discount of 7.5% for first month delivery and C$117/t in December with a 6.0% discount for prompt delivery. The decline in the quotation largely correspond to a change in the value of the Canadian dollar.

Prices in the United States, f.o.b. Canadian mines started in January at about US$86/s.t. for granular and rose to US$90/s.t. by December 1988.

International potash prices are still expected to rise moderately in 1989 with the differential between U.S. prices and world prices experiencing a further narrowing.

OUTLOOK

Already, a year ago, there was a general perception in the potash industry that 1986-87 was the worst period and that markets will start improving. Indeed they have, attaining both in volume and price the most optimistically forecast levels.

Weather in 1988 did not cooperate with the farmer, with adverse conditions experienced in many grain growing areas of the world. Of major longer term significance was the devastating North American drought. While American and Canadian grain production declined, exports continued strong throughout 1988 and resulted in a drawdown of agricultural stocks to abnormally low levels. Yet at the beginning of the year it was still expected, or rather hoped, that it will take three to four years to achieve a meaningful decline in the North American agricultural stocks.

Agronomists now expect planted grain acreage to increase in 1989 by 9% to 12%, versus previous forecasts of about 3%. In the case of corn, the increase is forecast at 13% to 14%. However, this should not result in a bumper grain crop, since average yields will still be below normal, as a result of soil moisture deficiency which will take more than one year to correct.

Potash consumption in the United States is likely to rise by 600 000 t to 1 Mt KCl above last year's level. Furthermore, some agronomists forecast good levels of potash consumption in the United States for 1990 and even 1991.

Canadian capacity utilization in 1988 was 73% compared to 66% in 1987. However, optimum capacity utilization of 90% will not be reached before the mid-1990s.

The U.S.S.R. increased its potash exports to western countries in 1988 at the expense of domestic deliveries and partially exports to COMECON countries. However, this trend is not expected to continue since after 1989 domestic Soviet needs are bound to take precedence over exports. On the longer term basis, it is expected that mine expansions in the U.S.S.R. will have run their course by the mid-1990s.

It is reasonable to expect a steady improvement in demand from most Latin American as well as Asian countries, particularly China, at an average annual rate of between 4% and 5%. Canadian producers will gain a high proportion of this incremental market so that Canadian "offshore" exports in the early 1990s will reach equality with North American sales.

However, it will take four to six years, depending on rapidly changing circumstances, before new additions to capacity are required anywhere in the world. Already ongoing, committed expansions will add another 2.0 Mt by 1991. This includes 0.4 Mt in Canada, replacing capacity lost to flooding in 1987. It is assumed that world demand for potash will resume an upward growth averaging between 2.0 and 2.4%/y between now and the year 2000.

Since it takes between five and eight years to bring new mines into production some companies are already examining mining opportunities for the mid-1990s. Modest expansions to existing mines can be instituted in a shorter time frame of about three years, so that such decisions may safely be deferred until the early 1990s. While opportunities are there, the potash mining industry must be vigilent against crowding too many development projects into a short time frame. It has been done in the past with tragic consequences.

TABLE 1A. CANADA, POTASH PRODUCTION, SHIPMENTS AND TRADE, 1986-87

	1986		1987	
	(tonnes)	($000)	(tonnes)	($000)
Production, potassium chloride				
Gross weight	10 938 161	..	12 116 935	..
K_2O equivalent	6 677 983	..	7 398 906	..
Shipments				
K_2O equivalent	6 752 709	584 304	7 668 384	745 009
Imports, fertilizer potash				
Potassium chloride				
United States	391	458	968	493
Potassium sulphate				
United States	25 668	4 822	11 642	2 492
Italy	338	94	131	36
West Germany	-	-	40	11
France	2 999	728	-	-
Total	29 005	5 644	11 813	2 539
Potassic fertilizer, n.e.s.				
United States	23 991	3 947	51 502	6 789
Potash chemicals				
Potassium carbonate	1 359	1 164	1 544	1 049
Potassium hydroxide	4 388	2 240	4 092	2 302
Potassium nitrates	4 037	2 097	4 521	2 243
Potassium phosphates	3 730	3 885	3 713	4 097
Potassium silicates	698	585	893	671
Total potassium chemicals	14 212	9 971	14 763	10 362
Exports, fertilizer potash				
Potassium chloride, muriate				
United States	5 876 482	425 620	6 028 110	513 415
People's Republic of China	310 842	27 224	794 460	68 486
Japan	564 439	56 240	738 241	68 308
Brazil	776 600	79 797	653 998	63 050
South Korea	394 630	39 361	532 336	47 488
Indonesia	224 386	23 489	334 903	30 967
Malaysia	193 458	19 615	288 956	26 204
Australia	176 838	17 645	237 197	20 387
India	469 227	47 254	208 018	19 448
Netherlands	41 661	4 155	178 566	17 839
Singapore	17 893	1 863	136 614	12 467
France	149 337	14 896	111 623	9 644
Denmark	85 943	8 083	102 306	9 393
Bangladesh	15 750	1 736	94 348	8 827
Taiwan	42 151	4 424	71 200	6 143
New Zealand	36 537	3 734	67 082	5 777
Norway	10 528	993	61 133	5 541
Colombia	13 713	1 013	49 600	4 902
Philippines	18 000	1 872	42 975	3 687
Ireland	14 108	1 648	33 290	2 874
Belgium-Luxembourg	77 099	7 838	33 148	2 852
United Kingdom	31 364	3 357	25 251	2 500
Italy	41 269	4 046	25 162	2 177
Mexico	49 209	5 078	22 000	1 896
Costa Rica	16 520	1 693	20 844	1 818
Jamaica	17 755	2 028	14 240	1 771
Guatemala	27 842	2 906	13 247	1 465
Haiti	-	-	15 750	1 350
South Africa	24 634	2 505	14 750	1 276
Other countries	175 821	17 961	33 703	3 222
Total	9 894 036	828 074	10 983 051	965 174

Sources: Statistics Canada; Energy, Mines and Resources, Canada.
- Nil; .. Not available; n.e.s. Not elsewhere specified.

TABLE 1B. CANADA, POTASH PRODUCTION, SHIPMENTS AND TRADE, 1988P

		1988P	
		(tonnes)	($000)
Production, potassium chloride			
Gross weight		..	..
K_2O equivalent		8 336 600	..
Shipments			
K_2O equivalent		8 070 400	1 058 716
Imports, fertilizer potash		**(Jan.-Sept.)**	
3104.20	Potassium chloride, in packages weighing more than 10 kg		
	United States	2 358	273
	West Germany	45	4
	Total	2 403	277
3104.30	Potassium sulphate, in packages weighing more than 10 kg		
	United States	4 065	1 307
	Italy	198	57
	West Germany	61	13
	Total	4 324	1 377
3104.90.00.10	Magnesium potassium sulphate		
	United States	9 736	1 653
	West Germany	10	3
	Total	9 746	1 656
3104.90.00.90	Other, potassic fertilizer		
	United States	1 643	780
	Other countries	45	59
	Total	1 688	839
Potash Chemicals			
2815.20	Potassium hydroxide (caustic potash)	4 428	2 348
2834.21	Potassium nitrate	3 835	1 965
2835.24	Potassium phosphates	1 770	1 946
2836.40	Potassium carbonates	1 388	941
2839.20	Potassium silicates	566	409
	Total potassium chemicals	11 987	7 609
Exports, fertilizer potash		**(full year)**	
3104.20	Potassium chloride in packages weighing more than 10 kg		
	United States	6 157 980	679 559
	People's Republic of China	1 465 253	150 986
	Brazil	666 440	73 599
	Japan	657 570	77 271
	South Korea	505 705	55 605
	Malaysia	376 120	41 336
	India	396 614	40 171
	Australia	257 174	28 473
	Singapore	219 132	23 235
	Indonesia	287 933	30 729
	Taiwan	185 201	20 392
	Chile	174 564	18 993
	Mexico	143 451	14 823
	United Kingdom	124 755	14 056

TABLE 1B (cont'd)

		1988P	
		(tonnes)	($000)
Exports (cont'd)			
	Philippines	92 379	9 923
	Bangladesh	83 062	8 655
	France	123 634	13 687
	Belgium	102 466	11 441
	Italy	54 863	6 093
	Denmark	88 659	8 408
	Venezuela	83 624	8 523
	Finland	57 051	5 652
	New Zealand	34 444	3 821
	Norway	30 077	3 074
	Netherlands	26 976	2 865
	Costa Rica	26 495	3 075
	Nigeria	27 995	2 952
	Guatemala	15 750	1 568
	Argentina	16 150	1 745
	Colombia	12 000	1 291
	Jamaica	13 528	1 721
	Other countries	44 941	3 403
	Total	12 507 049	1 365 250
3104.30	Potassium sulphate in packages weighing more than 10 kg		
	Philippines	5 444	1 262
	United States	1 857	397
	Total	7 301	1 659

Sources: Statistics Canada; Energy, Mines and Resources Canada.
P Preliminary; .. Not available.

TABLE 2. CANADA, POTASH PRODUCTION AND SALES BY GRADE[1] AND DESTINATION, 1986 AND 1987

	1987						1986
	Standard[2]	Coarse	Granular	Soluble	Chemical[3]	Total	Total
	(tonnes K_2O equivalent)						
Production	2 224 783	2 134 540	2 355 906	492 200	59 399	7 266 828	6 697 568
Sales							
Canada	17 946	204 731	265 790	11 070	..	499 537	327 379
United States	359 383	1 967 227	1 477 240	419 954	..	4 223 803	3 880 719
Offshore							
Argentina	608	-	-	-	..	608	3 043
Australia	9 161	31 388	126 300	-	..	166 850	126 897
Bangladesh	57 385	-	-	-	..	57 385	19 052
Belgium	-	-	-	-	..	-	6 968
Brazil	55 820	115 007	232 167	-	..	402 995	501 741
Chile	17 722	-	-	-	..	17 722	26 171
China	536 866	-	-	-	..	536 866	283 965
Colombia	11 543	22 938	-	-	..	34 481	15 995
Costa Rica	12 694	-	-	-	..	12 694	13 037
Denmark	67 770	-	1 500	-	..	69 267	51 830
Dom. Rep.	-	-	-	-	..	-	2 579
Ecuador	-	-	-	-	..	-	3 160
France	-	-	-	-	..	-	12 195
Guatemala	6 200	-	5 004	-	..	11 204	13 775
Holland	32 522	-	88 411	-	..	120 933	-
India	79 421	-	-	7 706	..	87 127	307 453
Indonesia	197 643	-	-	-	..	197 643	166 946
Ireland	-	-	-	-	..	-	7 036
Italy	-	-	-	22 704	..	22 704	32 445
Jamaica	-	3 258	4 109	-	..	7 366	8 689
Japan	163 691	86 050	66 323	137 413	..	453 476	352 987
Korea, South	293 488	-	-	20 613	..	314 107	224 131
Malaysia	222 865	3 071	16 008	-	..	241 945	130 865
Mexico	13 396	-	-	-	..	13 396	29 994
New Zealand	45 862	1 559	-	629	..	48 049	22 272
Norway	23 656	-	-	-	..	23 656	-
Pakistan	11	-	-	-	..	11	23
Peru	2 493	-	-	-	..	2 493	7 199
Philippines	35 731	-	-	-	..	35 731	10 346
Puerto Rico	-	-	-	-	..	-	2 293
South Africa	7 274	-	13 825	-	..	21 099	14 952
Spain	-	-	4 017	-	..	4 017	-
Sri Lanka	30 417	-	3 618	-	..	34 035	12 778
Switzerland	98 220	3 343	20 696	2 642	..	124 901	135 216
Taiwan	49 025	-	-	1 070	..	50 095	43 590
United Kingdom	681	-	-	-	..	681	2 662
Venezuela	-	-	-	-	..	-	42 555
Offshore total	2 072 162	266 613	581 978	192 776	..	3 113 528	2 612 379
Total sales	2 449 491	2 438 571	2 325 008	623 800	..	7 836 868	7 031 086

Source: Potash and Phosphate Institute.
[1] Common specifications are: standard -28 to +65 mesh, special standard -35 to +200 mesh, coarse -8 to +28 mesh, granular -6 to +20 mesh, each grading a minimum of 60% K_2O equivalent, soluble and chemical grade a minimum of 62% K_2O equivalent. [2] Standard includes Special Standard, sales of which were 213 649 t K_2O equivalent in 1986, and 243 269 t in 1987. [3] Chemical sales are included in standard grade sales and totalled 44 252 t in 1987.
- Nil; .. Not available.

TABLE 3. CANADA, POTASH PRODUCTION AND TRADE, FERTILIZER YEARS-ENDED JUNE 30, 1966, 1971, AND 1976-88

	Production[2]	Imports[1,2]	Exports[2]
	(tonnes K_2O equivalent)		
1966	1 748 910	31 318	1 520 599
1971	3 104 782	26 317	3 011 113
1976	4 833 296	16 445	4 314 150
1977	4 803 015	24 289	4 175 473
1978	6 206 542	26 095	5 828 548
1979	6 386 617	21 819	6 256 216
1980	7 062 996	20 620	6 432 124
1981	7 336 973	35 135	6 933 162
1982	6 042 623	25 437	5 400 662
1983	5 378 842	21 846	4 864 219
1984	7 155 599	17 934	6 730 733
1985	7 283 509	17 396	6 784 178
1986	6 519 777	12 837	6 479 678
1987	7 031 586	12 122	7 100 135
1988	7 839 625	14 486	7 315 318

Sources: Potash and Phosphate Institute; Canadian Fertilizer Institute.

[1] Includes potassium chloride, potassium sulphate, except that contained in mixed fertilizers. [2] Change of data source. Prior to 1978 figures were obtained from Statistics Canada.

TABLE 4. CANADA, POTASH PRODUCTION AND SALES IN 1987 AND BY QUARTERS, 1988

	Total (1987)	1988 1st quarter	 2nd quarter	 3rd quarter	 4th quarter
			(000 tonnes K_2O)		
Production	7 266.8	2 210.1	2 250.9	1 711.9	2 154.5
Sales					
North America	4 723.3	1 160.8	1 215.3	807.8	1 069.1
Offshore	3 113.5	910.5	1 092.1	879.4	910.7
Total	7 836.9	2 071.3	2 307.4	1 687.2	1 979.8
Ending Inventory					
Mine site	380.2	497.0	405.2	388.4	488.3
Offsite	755.0	849.2	778.6	793.3	868.1
Total	1 135.2	1 246.2	1 185.8	1 181.7	1 356.4

Source: Potash and Phosphate Institute.

TABLE 5. CANADA'S PRODUCTION, SHIPMENTS AND SALES OF POTASH, 1970-87 (RECONCILIATION TABLE)

	Production (1)	Production (2)	Shipments (3)	Sales (4)	Exports and Domestic Sales (5)	Differences (1) - (3)	Differences (1) - (4)	Differences (4) - (5)
			(000 tonnes K_2O)					
1970	3 173.3		3 102.8	3 051.5	3 203.4	+70.5	+121.8	-151.9
1971	3 572.9		3 628.4	3 605.2	3 646.8	-55.5	-32.3	-41.6
1972	3 927.7		3 494.6	3 709.4	3 706.7	+433.1	+218.3	+2.7
1973	4 262.0		4 453.8	4 787.4	4 348.9	-191.8	-525.4	+438.5
1974	5 480.5		5 776.1	5 778.6	5 784.0	-295.6	-298.1	-5.4
1975	5 435.7		4 673.4	4 638.2	4 645.3	+762.3	+797.5	-7.1
1976	4 995.9		5 215.4	5 173.1	5 284.2	-219.5	-177.2	-111.1
1977	6 088.6		5 764.2	5 678.9	5 864.8	+324.4	+409.7	-185.9
1978	6 109.6	6 123.5	6 344.0	6 463.2	6 096.1	-234.4	-353.6	+367.1
1979	6 704.7	6 714.7	7 074.4	7 155.4	6 870.8	-369.7	-450.7	+284.6
1980	7 302.9	7 300.2	7 201.2	7 110.7	6 815.6	+101.7	+192.2	+295.1
1981	7 146.6	7 174.6	6 548.7	6 336.5	6 472.9	+597.9	+810.1	-136.4
1982	5 351.8	5 207.9	5 308.5	5 051.5	4 677.9	+43.3	+300.3	+373.6
1983	5 929.5	5 928.9	6 228.3	6 556.7	5 852.8	-298.8	-627.2	+703.9
1984	7 794.0	7 748.7	7 527.0	7 068.1	7 447.0	+267.0	+725.9	-378.9
1985	6 694.5	6 636.7	6 661.1	6 522.3	6 413.4	+33.4	+172.2	+108.9
1986	6 678.0	6 697.7	6 752.7	7 023.1	6 362.8	-74.1	-345.1	+660.8
1987	7 398.9	7 266.7	7 668.0	7 837.0	7 199.1	-269.1	-438.1	+637.9
Cumulative 1970-87	104 047.1		103 422.6	103 546.8	100 692.5	+624.3	+500.1	+2 854.3

(1) Production as reported to Statistics Canada/EMR.
(2) Production as reported by the Potash and Phosphate Institute (PPI).
(3) Shipment is product that left the mine site (Statistics Canada).
(4) Sales are company sales directly from the mine or from regional warehouse facilities including some in the United States (as reported by PPI).
(5) Exports as reported by Statistics Canada plus domestic Canadian sales as reported by PPI.

TABLE 6. CANADA, POTASH SALES BY PRODUCT AND AREA, 1986 AND 1987

		Agricultural					Industrial			Total
		Standard	Coarse	Granular	Soluble	Total	Standard	Soluble	Total	Sales
		(tonnes K_2O equivalent)								
Alberta	1986	48	1 458	23 438	2 136	27 081	2 307	412	2 719	29 800
	1987	223	46	26 735	2 308	29 313	2 450	54	2 505	31 818
British Columbia	1986	-	358	11 859	81	12 298	-	-	-	12 298
	1987	34	66	1 184	54	1 337	-	-	-	1 337
Manitoba	1986	15	4 593	13 731	1 647	19 987	-	12	12	19 999
	1987	15	4 064	15 633	2 148	21 861	24	-	24	21 885
New Brunswick	1986	-	4 257	11 412	59	15 728	-	-	-	15 728
	1987	12	5 982	9 172	87	15 253	-	-	-	15 253
Nova Scotia	1986	15	289	3 352	-	3 657	-	-	-	3 657
	1987	-	-	6 408	-	6 408	-	-	-	6 408
Ontario	1986	217	74 639	43 969	2 820	121 646	7 627	1 012	8 639	130 285
	1987	153	168 953	64 345	2 132	235 583	10 546	307	10 853	246 436
Prince Edward Island	1986	-	855	9 546	-	10 402	-	-	-	10 402
	1987	-	-	10 671	-	10 671	-	-	-	10 671
Quebec	1986	1 667	16 003	68 152	182	86 004	434	-	434	86 438
	1987	41	21 737	95 560	27	117 364	935	12	947	118 311
Saskatchewan	1986	286	1 591	11 786	117	13 780	3 485	1 051	4 536	18 316
	1987	(70)	3 883	36 082	74	39 969	3 583	3 866	7 449	47 418
Newfoundland	1986	245	-	-	-	245	212	-	212	457
	1987	-	-	-	-	-	-	-	-	-
Totals	1986	2 493	104 045	197 247	7 043	310 828	14 065	2 487	16 552	327 380
	1987	408	204 731	265 790	6 830	477 760	17 538	4 239	21 777	499 537

Source: Potash and Phosphate Institute.
- Nil. (Brackets) indicate negative quantities.

TABLE 7. CANADA, POTASH INVENTORY, PRODUCTION, DOMESTIC SALES AND EXPORT SALES, 1987

			Domestic Sales		Export Sales			
					United States			
	Beginning Inventory	Production	Agricultural	Non-agricultural	Agricultural	Non-agricultural	Offshore	Total Sales
					(000 tonnes K_2O)			
January	1 536.6	529.4	119.3	1.3	463.3	15.1	201.3	800.3
February	1 299.4	615.1	33.1	1.6	321.2	17.7	237.9	611.5
March	1 342.1	709.8	30.2	1.2	378.8	23.2	351.8	785.2
April	1 279.3	688.4	51.0	1.5	495.7	18.5	290.3	857.0
May	1 106.1	709.4	49.6	1.4	304.6	16.3	264.0	635.9
June	1 188.2	636.1	28.6	2.3	429.5	24.9	257.8	743.1
Sub-total		3 888.2	311.8	9.3	2 393.1	115.7	1 603.1	4 433.0
July	1 142.8	316.9	16.6	1.9	137.4	17.2	260.2	433.3
August	915.5	531.7	21.6	1.2	315.8	15.4	230.0	584.0
September	933.7	640.4	50.2	1.5	346.5	18.7	210.3	627.2
October	959.7	701.8	26.9	1.9	210.6	20.0	312.3	571.7
November	1 088.2	641.0	24.0	3.2	208.0	17.5	208.5	461.2
December[1]	1 265.0	546.7	26.8	2.7	383.1	24.9	289.1	726.6
Sub-total		3 378.5	166.1	12.4	1 601.4	113.7	1 510.4	3 404.0
Total 1987		7 266.7	477.9	21.7	3 994.5	229.4	3 113.5	7 837.0
1986		6 697.7	305.9	16.4	3 880.6	210.7	2 609.5	7 023.1
% change 1987/86		+8.5	+56.2	+32.3	+2.9	+8.9	+19.3	+11.6

Source: Potash and Phosphate Institute.

[1] Inventory at the end of December 1987 was 1 135 190 t.

TABLE 8. CANADA, POTASH INVENTORY, PRODUCTION, DOMESTIC SALES AND EXPORT SALES, 1988

					Export Sales			
			Domestic Sales		United States			
	Beginning Inventory	Production	Agri-cultural	Non-agri-cultural	Agri-cultural	Non-agri-cultural	Offshore Total	Total Sales
	(000 tonnes K_2O)							
January	1 135.2	645.1	90.0	1.7	455.3	17.5	298.0	862.5
February	914.0	732.1	12.0	1.1	274.9	20.5	307.5	616.0
March	1 016.4	832.8	25.3	2.4	239.4	20.8	305.0	592.9
April	1 246.2	752.1	48.5	1.4	433.3	22.1	313.0	818.3
May	1 187.1	775.3	74.0	1.5	317.5	19.6	344.8	757.4
June	1 187.1	723.5	28.5	2.1	242.2	24.7	434.1	731.6
Sub-total		4 460.9	278.3	10.2	1 962.6	125.2	2 002.4	4 378.7
July	1 185.6	428.2	5.7	1.5	177.4	18.7	293.0	496.3
August	1 114.6	553.3	16.2	2.2	313.3	21.7	310.4	663.8
September	980.3	730.3	23.3	4.0	201.1	22.5	276.1	527.0
October	1 181.6	756.9	23.6	1.8	271.2	21.1	305.2	622.9
November	1 306.3	727.2	26.7	2.1	277.0	25.0	315.8	646.6
December[1]	1 390.0	670.5	18.6	1.3	374.0	21.9	289.7	705.5
Sub-total		3 866.4	114.1	12.9	1 614.0	130.9	1 790.2	3 662.1
Total 1988		8 327.3	392.4	23.1	3 576.6	256.1	3 792.6	8 040.8[2]
1987		7 266.7	477.9	21.7	3 994.5	229.4	3 113.5	7 837.0
% change 1988/87		+14.6	-17.9	+6.5	-10.5	+11.6	+21.8	+2.6

Source: Potash and Phosphate Institute of North America.

[1] Inventory at the end of December 1988 is estimated at 1 356 400 t. [2] PPI annual data show total sales of 8 106 200 t.

TABLE 9. CANADA, POTASH PRODUCTION AND VALUE (FORECAST 1988-2000)

	Capacity	Capacity Utilization	Production[1]	Unit Value $/t[2]		Value of Production $ millions		Implicit[3] Price Deflator
				Current	Constant	Current	Constant	
	(000 t K_2O)	(%)	(000 t K_2O)	($)	(1985 $)	($)	(1985 $)	(1985 base)
1970	6 888	45	3 013	35	104	109	313	33.5
1971	7 522	48	3 628	37	107	134	388	34.6
1972	7 522	46	3 495	39	107	136	374	36.6
1973	7 522	59	4 454	40	101	178	450	39.8
1974	7 522	77	5 776	53	116	306	670	45.5
1975	7 522	62	4 673	77	154	360	720	50.0
1976	7 522	69	5 215	68	125	355	652	54.3
1977	7 575	76	5 764	70	121	403	697	57.7
1978	7 575	84	6 344	80	131	508	831	61.3
1979	7 850	90	7 074	104	154	736	1 089	67.4
1980	7 895	91	7 201	142	191	1 023	1 375	74.5
1981	8 060	81	6 549	152	184	995	1 205	82.6
1982	8 500	62	5 309	119	133	632	706	89.8
1983	8 980	70	6 294	103	109	648	686	94.2
1984	9 320	81	7 527	115	118	866	888	97.2
1985	9 780	68	6 661	95	95	633	633	100.0
1986	10 580	64	6 753	83	81	560	547	102.6
1987	11 020	70	7 668	97	91	744	698	107.0
1988	11 430	71	8 070	131	118	1 057	952	111.4
1989	11 550	72	8 300	135	116	1 120	963	116.6
1990	11 800	72	8 500	145	120	1 233	1 020	120.8
1991	11 800	73	8 630	158	125	1 364	1 079	126.1
1992	11 800	75	8 880	179	135	1 586	1 199	132.5
1993	11 800	79	9 280	186	135	1 726	1 252	138.1
1994	11 800	85	10 080	195	135	1 966	1 361	144.4
1995	11 800	89	10 450	204	135	2 132	1 410	151.0
1996	12 100	90	10 800	213	135	2 300	1 458	157.7
1997	12 500	90	11 200	213	135	2 498	1 512	165.0
1998	13 000	90	11 680	233	135	2 721	1 577	172.4
1999	13 500	90	12 100	243	135	2 940	1 634	180.2
2000	14 100	90	12 700	254	135	3 226	1 715	188.1

---

[1] "Shipments" as shown by Statistics Canada as a proxy for production. [2] Value of shipments f.o.b. mine as reported by companies to Statistics Canada. [3] Implicit Price Deflator to 1987 is the GDP Implicit Price Index, 1981=100 and re-indexed to 1985. Forecast Deflator 1988-2000 is by the WEFA Group.

TABLE 10. WORLD POTASH PRODUCTION

	1982	1983	1984	1985	1986	1987^p	1988^e
				(000 tonnes K_2O)			
Brazil	-	-	-	6	11	37	75
Canada	5 352	5 930	7 749	6 637	6 697	7 267	8 328
Chile	-	-	-	-	-	-	5
China	26	25	20	20	20	25	30
France	1 706	1 539	1 740	1 750	1 610	1 539	1 504
Germany Dem. Rep.	3 200	3 341	3 463	3 465	3 485	3 510	3 510
Germany, Fed. Rep.	2 057	2 419	2 645	2 583	2 162	2 201	2 290
Israel	942	929	1 130	1 172	1 240	1 265	1 242
Italy	115	133	127	143	109	122	125
Jordan	9	168	291	545	662	722	786
Spain	694	659	677	645	702	740	765
U.S.S.R.	8 079	9 294	9 776	10 367	10 228	10 889	11 000
United Kingdom	240	303	319	337	391	429	470
United States	1 784	1 429	1 564	1 296	1 202	1 262	1 380
	24 489	26 163	29 501	28 960	28 551	30 008	31 510

Sources: International Fertilizer Industry Association Ltd.; U.S. Bureau of Mines; Energy, Mines and Resources Canada. Production in Canada conforms with the PPI statistics.
^{P} Preliminary; ^{e} Estimated; - Nil.

TABLE 11. CANADA POTASH, CURRENT SITUATION AND FORECAST

	Actual						Forecast	
	1983	1984	1985	1986	1987	1988^e	1989	1990
				(000 tonnes K_2O)				
Capacity	8 980	9 320	9 780	10 580	11 020	11 430	11 550	11 800
Production	5 928	7 749	6 636	6 698	7 267	8 328	8 400	8 600
Capacity Utilization (%)	66	83	68	63	66	73	73	73
Sales:	6 557	7 071	6 577	7 023	7 837	8 030	8 400	8 600
of which: Domestic	385	436	434	322	480	420	450	500
United States	4 146	4 090	4 215	4 091	4 224	3 830	4 200	4 200
Offshore	2 026	2 545	1 928	2 610	3 114	3 780	3 750	3 900
End-year stocks	862	1 543	1 766	1 537	1 135	1 360	1 400	1 400
World Production	26 163	29 501	28 960	28 551	29 309	31 500	31 700	32 050
Canada/World Production Ratio (%)	22.6	26.3	22.9	23.5	24.7	26.4	26.5	26.8

^{e} Estimated.

TABLE 12. CANADA, POTASH MINES - CAPACITY PROJECTIONS

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
	(000 tonnes K_2O equivalent)											
Potash Corporation of Saskatchewan												
- Allan (60%)	575	575	575	575	575	575	575	575	575	575	575	575
- Cory	830	830	830	830	830	830	830	830	830	830	830	830
- Esterhazy (25% of IMC)	580	580	580	580	580	580	580	580	580	580	580	580
- Lanigan	690	690	1 240	1 740	2 090	2 090	2 090	2 090	2 090	2 090	2 090	2 090
- Rocanville	1 160	1 160	1 160	1 160	1 160	1 160	1 160	1 160	1 160	1 160	1 160	1 160
Sub-total	3 835	3 835	4 385	4 885	5 235	5 235	5 235	5 235	5 235	5 235	5 235	5 235
Central Canada Potash	815	815	815	815	815	815	815	815	815	815	815	815
Cominco Ltd.	655	815	815	815	815	815	815	815	815	815	815	815
International Minerals & Chemical Corporation (75%)	1 745	1 745	1 745	1 745	1 745	1 745	1 745	1 745	1 745	1 745	1 745	1 745
Kalium Chemical	1 055	1 055	1 055	1 245	1 245	1 245	1 245	1 245	1 245	1 245	1 245	1 245
Potash Company of America	630	630	630	100	30	150	400	400	400	400	400	400
Saskterra Fertilizers Ltd. (Allan 40%)	385	385	385	385	385	385	385	385	385	385	385	385
Sub-total	5 285	5 445	5 445	5 105	5 035	5 155	5 405	5 405	5 405	5 405	5 405	5 405
Total Saskatchewan	9 120	9 280	9 830	9 990	10 270	10 390	10 640	10 640	10 640	10 640	10 640	10 640
Denison Mines Limited, N.B.	-	200	450	650	780	780	780	780	780	780	780	780
Potash Company of America	200	300	300	380	380	380	380	380	380	380	380	380
Total New Brunswick	200	500	750	1 030	1 160	1 160	1 160	1 160	1 160	1 160	1 160	1 160
Canada	9 320	9 780	10 580	11 020	11 430	11 550	11 800	11 800	11 800	11 800	11 800	11 800

Note: Capacity means "rated" capacity; under normal conditions Canadian mines operate at about 90% of rated capacity.
- Nil.

Primary Iron and Ferrous Scrap

T.R. McINNIS

PRIMARY IRON

Primary iron is the raw material used to make steel and other iron products such as castings. It includes blast furnace iron, direct reduced iron and electric smelted iron. Recycled ferrous scrap is a very important and increasingly sophisticated raw material in steel production, as about 50% of the iron units used to make steel in Canada are sourced from scrap.

Primary iron is produced in Canada by three main processes. The bulk of production is by blast furnaces. Iron produced by electric smelting and by direct reduction are next in importance, with equivalent quantities produced by each process. A secondary process is cupolas, which are melting furnaces used in the foundry industry.

CANADIAN EVENTS

Blast Furnace Iron

Canadian production of blast furnace iron in the first 10 months of 1988 decreased to 7.66 Mt compared to 8.17 Mt in the same period of 1987, in spite of a 1.4% increase in steel production in 1988.

This situation is explained by recent increases in the use of continuous casting equipment which increases the yield of product from molten steel. That is, continuous casters allow up to 10-15% more finished product to be produced from each tonne of molten steel. Since less molten steel is needed, less molten blast furnace iron, or pig iron as it is commonly called, is required. Another major factor was increased production of steel by companies that operate electric furnaces to melt scrap. In the first 10 months of 1988, electric steel was 32.9% of production compared to 29.5% in the same period of 1987.

The Canadian steel industry has 12 blast furnaces with a total capacity of 12.2 Mt. Associated with these furnaces are 866 coke ovens with a capacity of 5.3 Mt/y. Virtually all of the blast furnace iron is used by the integrated steel companies for the production of steel.

Electric Smelting Iron

Another source of primary iron is the nine electric furnaces at the ilmenite smelting facility operated by QIT-Fer et Titane Inc. at Tracy, Quebec. These furnaces have the capacity to produce 700 000 t/y of iron as a coproduct with titanium dioxide. This iron is used to produce three products: a range of specialty pig iron grades, which are sold mainly to the foundry industry; iron powder used by the powder metallurgy industry; and continuous cast steel billets sold to the steel industry for rerolling. This facility operated at capacity during 1988.

Direct Reduced Iron (DRI)

DRI is a semi-metallic product made by reducing iron ore in the solid state to approximately 95% metallics. Sidbec-Dosco Inc. has one operating Midrex DRI plant at Contrecoeur, Quebec. This plant has a capacity to produce 750 000 t/y and operated at close to its capacity during 1988. The DRI together with scrap is used to produce steel at the company's electric furnace steel mill.

INTERNATIONAL EVENTS

Blast Furnace Iron

In the United States, pig iron production increased to the point where shortages of coke developed, requiring the importation of considerable tonnages. U.S. steel production in the first 10 months of 1988 increased almost 15% over the same period in the previous year. This increase was attributed to lower levels of imports, improved exports and high domestic demand for steel.

T.R. McInnis is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 992-8438.

Steel production in the rest of the world also increased. The member countries of the International Iron and Steel Institute increased output by a total of 9.9% in the first 10 months of 1988. ECC production increased 8.8% and Japan's was up 9.0%. There was a comparable increase in the production of pig iron, which was reflected in an increased consumption of iron ore.

DRI Developments

Midrex plants account for over 60% of world DRI production; HYL-I and HYL-III plants are the second most important. Total DRI production was estimated at 15 Mt in 1988, or about 3% of world crude steel production. With electric furnace steel production continuing to increase, and current high prices for scrap, the proportion of DRI used should grow. DRI's inherent advantages of high purity and controlled chemistry have always been valued but, as long as ferrous scrap prices remained low, the growth potential for the product was limited. This situation is now changed as scrap is expected to remain in short supply for the next decade. The availability of hot metal from blast furnaces is likely to decrease as older equipment reaches the end of its economic life, and since the industry will wait for the new reduction technologies to be commercially proven, the shortfall must be supplied by scrap and DRI.

World production of DRI increased an estimated 9.8% compared to 1987 quantities. This increase was from established capacity plus new capacity that came on stream, especially in the Soviet Union. An additional 5.9 Mt of capacity is under construction, and there is a further 5.9 Mt of capacity which was under construction, but has been suspended for a variety of reasons. A major project, in the Guayana region of Venezuela, is in the feasibility study stage of planning. This project would have two Midrex MEGAMOD plants with a total capacity of 2 Mt/y of DRI. They would be part of a complex with 3 Mt/y pelletizing capacity, a Hot Briquetted Iron plant, and an electric furnace steel mill with a capacity to produce 1 Mt/y of continuous cast slab. The principals in this proposal are Corporacion Venezolana de Guayana (CVG) and Kobe Steel, Ltd. (KSL). The projected start up for the project, which is called Comsigud, is late 1993.

NEW PRIMARY IRON TECHNOLOGIES

A number of new processes that provide an alternative to the traditional blast furnace have been developed. These processes are generally some form of direct smelting. They have economic and environmental advantages over the coke-oven blast furnace method, which requires coke and agglomerated iron ore. Agglomerated ore such as pellets is more expensive than iron ore concentrates, largely due to the energy used to indurate the iron ore pellets. As well, coke production requires high grade metallurgical coal, whereas many direct smelting technologies require only pulverized lower grades of coal. A further consideration is environmental protection legislation that makes new coke ovens very expensive to build and to operate. Direct smelting processes have been engineered from original concepts to be environmentally compliant. Another advantage is the much smaller minimum economic size of direct smelting plants, an important capital cost consideration.

Many direct smelting processes such as the Corex process, the XR process by Kawasaki Steel Corporation, and Direct Bath smelting of iron ore, a joint venture of CRA Limited of Australia, Kloeckner Slahlhorschung of West Germany, and the Elkem Polar Process by Elkem A/S of Norway, have reached technical maturity, appear economically viable, and await verification at commercial scale.

OUTLOOK

Canadian production of primary iron is expected to decline somewhat during the next 2 to 3 years, even though steel production is forecast to remain close to current levels. The main factors affecting iron production are increased use of continuous casting equipment, and competition from electric furnace steel producers that utilize mainly scrap.

Nevertheless, in the medium term, 5 to 10 years, primary iron production should increase as Canadian steel production increases in the context of greater trade with the United States under the Free Trade Agreement. Free Trade is expected to stimulate the domestic steel-intensive secondary manufacturing industries as well as provide good potential for exports of steel mill products to the United States. The U.S. market still imports over 25% of its steel requirements and the Canadian steel industry is now in an excellent position to displace some of the tonnage that the United States imports from offshore. The existence of this potential was indicated by reports that the Canadian industry turned away many U.S. orders to avoid aggravating the protectionist sentiment that exists in the United States. Under Free Trade it is anticipated that these restraints will diminish.

FERROUS SCRAP

CANADIAN EVENTS

Canadian and U.S. demand for scrap remained high throughout 1988. This situation was a reflection of continued high demand for steel, especially in the United States. In Canada, total raw steel production during the first 11 months of 1988 was 13.6 Mt, up 1.4% from the same period last year.

In Canada the steel industry consumed 6.4 Mt of scrap in the first 10 months of 1988, compared to 5.9 Mt in the same period of 1987. Of this total 2.7 Mt was internally generated and 3.7 Mt was purchased. The percentage of purchased scrap used by steelmakers increased 14% in 1988.

PRICES

The weekly composite price for shredded scrap as quoted by the American Metal Market was between US$120/t and US$125/t in January, rose to a high of US$137 in February, fell to US$118 in June, hit a second high of US$137 in August, and closed the year at about US$130. The prices in Canada followed the same trends but did not reach as high a level.

Factors that contributed to continued high prices for ferrous scrap included:

- increased use of continuous casting in both Canada and the United States;
- an increased percentage of steel produced from electric furnace mills;
- continuing good demand for steel in Canada;
- large increases in U.S. steel production;
- less steel imported by the United States;
- increased exports of steel by the United States; and
- relatively low value for North American currencies, which stimulated exports of scrap overseas.

TRADE

Canada has been more than self-sufficient in scrap but there are regional differences in supply and consumption that result in significant trade between Canada and the United States. A high percentage of scrap, in excess of eastern Canadian needs, is exported to markets in the north-eastern United States, while the western Canadian market, which is generally deficient in local scrap, imports it from the American northwest and central regions. Scrap supply was a problem for the steel companies in western Canada throughout 1988.

The ferrous recycling industries in Canada and the United States share what they consider to be a single market. There are few restraints to the movement of scrap across the border and, consequently, prices in the United States have a major impact on those in Canada. During the last three years, 90% of Canadian scrap exports have gone to the United States, and virtually all Canadian imports originate in the United States.

Canada's recycling industry is efficient, quite highly mechanized, and competitive internationally. The world market for ferrous scrap is very competitive and tends to fluctuate widely from year to year. Offshore countries which have a history of buying Canadian scrap include South Korea, Spain, Italy and Japan.

CANADIAN INDUSTRY STRUCTURE

The Canadian ferrous scrap industry comprises approximately 600 firms. These companies collect, store and process the ferrous scrap for sale to the user industries. Most of these firms are small and are involved only in the simple collection of scrap. Dealers who are also involved in the sorting and storage of scrap are fewer in number, while those who engage in capital intensive scrap processing total only about 15. Scrap processing requires heavy equipment such as mechanical shredders, shears, presses and bundlers. This segment of the scrap industry produces the grades and types of scrap needed by the steel mills. A new competitively sized processor would have to spend in excess of $10 million on capital equipment today.

Autobody shredding equipment represents a significant capital investment in the scrap industry. There are presently 15 shredders installed in Canada, which in aggregate have the capacity to process about 1.3 million cars per year.

Statistical process control has been implemented at most of the large processors in response to market demand for higher quality scrap. Scrap is such an important raw material that it is common for Canadian steel producers to hold equity in scrap processing companies in order to reduce the risk of supply problems, and to assure quality control.

SCRAP CLASSIFICATION

The producers of ferrous scrap describe unprocessed scrap by its origin. "Home scrap" is produced in the manufacture of steel mill products, whereas "prompt industrial scrap" is generated by the secondary manufacturing industry. "Obsolete scrap" comes from discarded machinery, equipment and structures.

Prompt and obsolete scrap is generally processed by the recycling industry and is sorted into a number of product classes for which standards have been written by the Canadian Association of Recycling Industries.

Scrap classification is based on factors such as size, type of material, cleanliness, and residual alloying elements. The most common grades are as follows:

Scrap Products[1]

Class No.	Grade and Type
100	No. 1 Heavy Melting Steel
101	No. 1 Hydraulic Bundles
102	No. 1 Bushelling Prepared
103	No. 2 Heavy Melting Steel
104	Plate and Structural Steel
105	No. 2 Hydraulic Bundles
106	Hydraulic Silicon Bundles
107	No. 2 Bushelling Prepared
108	No. 1 Bushelling (Clips)
109	Short Shovelling Steel Turnings (Crushed)
110	Machine Shop Turnings
111	Mixed Turnings and Borings
112	Cast Iron Borings
113	No. 1 Shredded Scrap
114	No. 2 Shredded Scrap
115	Briquetted Steel Turnings, Alloy Free
116	Briquetted Steel Turnings, Alloyed
117	Foundry Steel

USES

Most ferrous scrap is used in electric furnace steel mills and integrated mills for the production of steel. The foundry industry is the second largest market for scrap. Minor markets include the production of iron powders, sinter, ferroalloys and abrasives.

Scrap used in the electric furnace steel industry must be carefully selected in order to minimize the melting time and the consequent cost of energy per tonne, and to maximize the furnace productivity. Depending on the grade of scrap, it can take from 1100 to 1200 kg of scrap to produce 1000 kg of steel. Tramp elements in scrap are a larger problem in electric furnaces than in integrated mills because there is less opportunity to remove them by oxidation and slagging, or to dilute them in the melt by addition of pig iron. Certain elements like tin are more difficult to remove than others. Thus, scrap grades low in tramp elements are preferred by electric furnace mills.

Open-hearth and basic oxygen furnaces (BOF) provide more scope for steel refining. In these, scrap can be added in proportions of about 50% and 30% respectively. In a BOF scrap is necessary to absorb the energy released when the carbon in the molten iron is removed by oxidation. The exothermic energy is sufficient to melt as much as 30% scrap. Apart from the saving in energy, ferrous scrap is usually much cheaper than iron produced in a blast furnace. Therefore, integrated mills focus some of their research effort on optimizing the amount of scrap charged to their steel furnaces.

---

[1] From Canadian Association of Recycling Industries.

On balance, integrated steel operations have more flexibility than electric furnaces with respect to the percentage of scrap in furnace feed and they are also less dependent on scrap availability and price. For example, in periods of high demand, when integrated mills operate near capacity, scrap usage is often maximized to boost steel production even if scrap prices are high. The reverse situation may apply when steel demand is low. Scrap use is governed by the need to absorb blast furnace iron at a minimum operating rate. In this case it would be necessary to restrict scrap use to avoid over-production, even if the scrap was available at a very low price.

The ratio of purchased to internally-generated scrap in an integrated steel mill varies from year to year. In recent years, this ratio has varied from 0.93 to 1.17. The demand for purchased scrap may be dictated not only by considerations of minimum operating rates for blast furnaces, but also by the need to meet contractual purchases of iron ore and metallurgical coal. Such decisions may have been made in 1982 when the amount of purchased scrap that was used per tonne of steel was unusually low, even though the price of scrap was especially depressed. The expanding use of continuous casting equipment will more heavily influence the ratio in the future.

The increasing use of continuous casting, and improvements in BOF will tend to reduce the levels of internally generated scrap and/or increase the demand for purchased scrap.

In the case of the electric furnace steel industry, the price-demand relationship is much more direct because ferrous scrap is the principal raw material. Consequently, electric furnace mills can produce steel at considerably less cost than integrated mills in periods of low steel demand and low scrap prices, allowing them to capture market share and remain profitable. Many companies in this industry have been installing ladle refining facilities to improve the quality of their products, thereby allowing them to compete with the integrated mills over a larger product range.

OUTLOOK

Scrap prices may soften slightly in 1989 because Canadian demand for steel is expected to moderate. Canadian scrap prices should be supported by prices in the United States, where steel production is expected to remain considerably higher than in the years prior to 1988 due to restrictions on steel imports. In 1988, U.S. domestic production of steel increased by about 15%.

Integrated and electric furnace mills are experiencing rapid technological change, which will have a long-term impact on the scrap market. Recent research and development efforts have focused on increasing the amount of scrap that can be used in the basic oxygen furnace. New developments that improve the existing processes include systems in which fuel and oxygen are blown into the BOF to preheat the scrap charge, and Lance Bubbling Equilibrium (LBE) equipment in which inert gases are blown through the bottom of a BOF-type vessel. The more efficient mixing created by the LBE system results in higher yields, increases the amount of scrap that can be charged, and improves the quality of the steel. LBE equipment is being installed in a number of Canadian furnaces.

The market for scrap and the amount of scrap purchased by integrated mills also vary with the amount of scrap that is produced within the steel plant. The introduction of continuous casting has considerably reduced the proportion of internally generated or "home" scrap. Yields from molten crude steel to finished steel can increase by almost 20% when continuous casting is used instead of ingot casting.

Technical developments in the electric furnace mills have centered on the treatment of the steel in a separate holding vessel, a process called ladle metallurgy. This technique frees the main furnace for more primary production, and allows a more precise final treatment to adjust the chemistry of the steel. The improved products will allow electric furnace mills to capture a greater share of the steel market and thereby increase the demand for scrap.

Another technology that could be rapidly adopted by the industry is the continuous casting of thin slab that could be easily rolled into sheet products. Currently, sheet can be produced only by integrated mills. Nucor Corporation of the United States is constructing a mill based on the "thin slab casting" technology, with initial production scheduled for May or June 1989.

Scrap usage in 1989 is expected to be close to levels of 1988. In the medium-term, to 1995, usage should increase 4-5%/y as more continuous steel is produced and a greater percentage of the steel made in North America is produced in electric furnaces. The growth rate after 1995 is forecasted to slow to approximately 2%/y.

For the scrap recycling industry, the anticipated rising demand for higher quality scrap, especially in terms of low levels of tramp elements and more desirable product forms, will likely require the installation of more sophisticated process equipment. This could include x-ray spectrometers to analyze scrap, mechanical separators, high pressure bailers and briquetting machines for the production of high density product, and better shredders that would improve the separation of ferrous metal from nonferrous metals and nonmetallic components, such as in processing obsolete automobiles.

PRICES FOR RAW MATERIALS AND SELECTED STEEL PRODUCTS, 1986-88[1]

	1986	1987	1988
		(US$)[4]	
Raw Materials			
Iron ore pellets, Lake Erie base price, per metric iron unit[2]	86.9	72.4	72.4
Coal, metallurgical, imported from United States for Ontario steel mills, per tonne f.o.b.[3]	55.2	49.2^{r}	50.80^{e}
Scrap, Number 1 heavy melting, per tonne Pittsburg, United States	80.8	90.98^{r}	114.46
Direct reduced iron, per tonne	115-135	115-135	115-135
Basic pig iron, per tonne	213.00	213.0	
Iron and steel scrap Price index 1981=100, D614305	100.1	103.7^{r}	121.8P

Sources: Statistics Canada; Skillings Mining Review; Iron Age; Energy, Mines and Resources Canada.

[1] Prices in effect at end of December of each year. [2] One iron unit equals one percent of a tonne. Hence, iron ore pellets with a grade of 65% iron would contain 65 iron units per tonne. [3] International Review weighted average. [4] Average.

P Preliminary; ^{r} Revised; ^{e} Estimated; f.o.b. Free on board.

TABLE 1. CANADA, IMPORTS OF STEEL SCRAP, BY PROVINCE OF ENTRY, 1985-87

		1985		1986		1987	
		World	United States	World	United States	World	United States
Nova Scotia	tonnes	-	-	38	38	-	-
	$000	-	-	10	10	-	-
New Brunswick	tonnes	109	109	65	65	67	67
	$000	19	19	7	7	15	15
Quebec	tonnes	27 548	27 368	31 770	31 757	22 802	22 751
	$000	2 897	2 727	3 521	3 519	2 692	2 684
Ontario	tonnes	402 019	402 019	274 054	273 988	249 314	249 101
	$000	38 691	38 691	28 458	28 374	32 931	32 739
Manitoba	tonnes	41 886	41 886	21 568	21 568	21 035	21 035
	$000	3 420	3 420	1 420	1 420	1 754	1 754
Saskatchewan	tonnes	83 785	83 785	42 006	42 006	105 976	105 976
	$000	6 888	6 888	3 620	3 620	7 889	7 889
Alberta	tonnes	19 919	19 919	19 939	19 939	11 353	11 353
	$000	1 830	1 830	1 875	1 875	1 043	1 043
British Columbia	tonnes	2 413	2 413	5 369	5 369	4 102	4 102
	$000	265	265	446	446	428	428
Total	tonnes	577 678	577 499	394 809	394 731	414 649	414 386
	$000	54 010	53 841	39 356	39 271	46 753	46 553

Source: Statistics Canada.
- Nil.
Totals may not add due to rounding.

TABLE 2. CANADA, EXPORTS OF STEEL SCRAP, BY PROVINCE OF LADING, 1985-87

		1985		1986		1987	
		World	United States	World	United States	World	United States
Newfoundland	tonnes	3 827	-	1 302	-	7 028	-
	$000	553	-	86	-	656	-
Nova Scotia	tonnes	32 695	8 147	1 575	1 563	5 712	5 406
	$000	4 112	1 222	247	244	1 123	1 071
Prince Edward Island	tonnes	-	-	104	104	-	-
	$000	-	-	15	15	-	-
New Brunswick	tonnes	2 811	2 811	10 669	2 883	3 147	3 017
	$000	388	388	1 472	361	694	651
Quebec	tonnes	245 469	17 491	177 412	25 922	116 775	27 997
	$000	29 778	2 068	15 299	3 239	13 848	4 019
Ontario	tonnes	414 688	373 167	538 491	466 004	626 854	502 734
	$000	38 149	32 421	50 725	42 987	79 437	64 574
Manitoba	tonnes	991	991	5 248	5 248	7 408	7 355
	$000	93	93	813	813	780	772
Saskatchewan	tonnes	-	-	86	-	6 016	6 016
	$000	-	-	26	-	1 148	1 148
Alberta	tonnes	583	170	299	168	1 048	632
	$000	193	24	100	63	196	114
British Columbia	tonnes	108 746	101 795	97 602	81 070	129 000	116 531
	$000	10 886	9 842	11 290	8 536	13 049	10 658
Yukon	tonnes	230	230	1 429	127	-	-
	$000	41	41	143	7	-	-
Total	tonnes	810 040	504 802	834 218	583 089	902 987	669 688
	$000	84 193	46 100	80 216	56 265	110 931	83 007

Source: Statistics Canada.
- Nil.
Totals may not add due to rounding

TABLE 3. CANADA, EXPORTS OF STAINLESS STEEL SCRAP, BY PROVINCE OF LADING, 1985-87

		1985		1986		1987	
		World	United States	World	United States	World	United States
Newfoundland	tonnes	-	-	-	-	-	-
	$000	-	-	-	-	-	-
Nova Scotia	tonnes	74	-	211	-	1 131	675
	$000	67	-	236	-	1 072	750
New Brunswick	tonnes	120	-	115	27	1 138	1 112
	$000	105	-	167	79	369	348
Quebec	tonnes	4 301	1 507	3 602	2 004	2 975	1 748
	$000	3 725	1 294	2 769	1 302	2 550	1 546
Ontario	tonnes	21 850	9 497	20 594	7 103	18 441	6 653
	$000	16 775	6 479	17 457	4 949	16 394	4 462
Manitoba	tonnes	352	205	247	247	1 838	1 659
	$000	263	130	170	170	409	211
Saskatchewan	tonnes	-	-	4	4	18	18
	$000	-	-	8	8	12	12
Alberta	tonnes	2	-	171	163	177	140
	$000	60	-	146	139	148	118
British Columbia	tonnes	1 520	368	2 159	477	2 631	524
	$000	1 194	143	1 583	287	1 840	286
Total	tonnes	28 218	11 577	27 104	10 026	28 349	12 530
	$000	22 190	8 046	22 536	6 935	22 794	7 733

Source: Statistics Canada.
- Nil.
Totals may not add due to rounding.

TABLE 4. CANADA, CRUDE STEEL PRODUCTION, SHIPMENTS AND TRADE, 1986-88

	1986	1987[r]	1988[e]
	(tonnes)		
Furnace capacity, January 1[1]			
Steel ingot			
Basic open-hearth	1 907 200	1 000 000	750 000
Basic oxygen converter	11 279 000	11 279 000	11 810 000
Electric	5 586 450	5 563 450	6 253 450
Total	18 772 650	17 842 450	18 813 450
Steel castings	797 053	799 030	399 352
Total furnace capacity	19 569 703	18 641 480	19 212 802
Production			
Steel ingot			
Basic open-hearth)			
Basic oxygen)	9 939 033	10 217 000	10 255 660
Electric	4 048 539	4 405 280	4 800 676
Total	13 987 572	14 622 161	15 056 336
Continuously cast, included in total above	6 456 093	7 215 774	10 476 312
Steel castings[2]	93 833	114 886	137 685
Total steel production	14 081 405	14 737 047	14 918 651
Shipments from plants			
Steel castings	83 233	100 378	128 000
Rolled steel products	11 661 843	12 748 778	13 261 522
Total	11 745 076	12 849 156	13 389 522
	(000 tonnes)		
Exports, equivalent steel ingots[3]	3 777.7	4 104.6	
Imports, equivalent steel ingots[3]	2 443.3	3 060.7	

Source: Statistics Canada.

[1] The capacity figures, as of January 1 in each year, take into account both new capacity and obsolete capacity anticipated for the year. [2] Produced mainly from electric furnaces. [3] Does not include fabricated steel product, steel forgings, pipe and wire.

[r] Revised; [e] Estimated.

TABLE 5. CANADA, PIG IRON PRODUCTION, SHIPMENTS, TRADE AND CONSUMPTION, 1986-88

	1986	1987r	1988
	(tonnes)		
Furnace capacity January 1[1]			
Blast	12 792 000	11 689 000	12 229 000
Electric	700 000	700 000	700 000
Total	13 492 000	12 389 000	12 929 000
Production			
Basic	..	..	..
Foundry iron[2]	..	..	..
Total	9 248 530	719 289	9 498 264
Imports			
Tonnes	11 814	9 794	..
Value ($000)	3 419	3 165	..
Exports			
Tonnes	519 562	446 950	..
Value ($000)	115 346	109 410	..
Consumption of pig iron			
Steel furnaces[3]	9 285 247	9 737 133	..
Consumption of iron and steel scrap			
Steel furnaces	6 948 243	7 143 453	7 460 000

Sources: Statistics Canada; Primary Iron and Steel (monthly).

[1] The capacity figures, as of January 1 in each year, take into account both new capacity and obsolete capacity anticipated for the year. [2] Includes malleable iron. [3] Includes pre-reduced iron.

r Revised; .. Withheld to avoid disclosing company proprietary data.

TABLE 6. CANADIAN CONSUMPTION OF IRON AND STEEL SCRAP

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
	(000 tonnes)									
Used in steel furnaces	7 076	7 250	7 501	6 845	5 492	6 449	7 383	7 034	6 948	7 143
Used in iron foundries	518	604	470	500	448	416	552	551	578r	590e
Other[1]	865	868	770	926	837	475	500	550	300e	325e
Total	8 459	8 722	8 741	8 271	6 777	7 337	8 435	8 135	7 826	8 058

Sources: 1982 Annual Census of Manufactures. 1983 and 1984 Catalogue 41-001 Primary Iron and Steel.

[1] Includes mainly steel pipe mills, motor vehicle parts, and railway rolling stock industries.

P Preliminary; r Revised; e Estimated.

TABLE 7. AUTOMOBILE SHREDDERS IN CANADA

Company	Location	Capacity (tonnes/month)
Intermetco Limited	Hamilton, Ontario	8 000
United Steel and Metal, division of USACO Limited	Hamilton, Ontario	5 000
Bakermet Inc.	Ottawa, Ontario	8 000
Industrial Metal, division of Co-Steel Inc.	Toronto, Ontario	10 000
Zalev Brothers Limited	Windsor, Ontario	8 000
Sidbec-Feruni inc.	Contrecoeur, Quebec	8 300
Fers et Métaux Recyclés Ltée	Longueuil, Quebec	4 000
	Laprairie, Quebec	4 000
Associated Steel Industries Ltd.	Montreal, Quebec	8 000
Native Auto Shredders	Regina, Saskatchewan	6 000
Cyclomet	Moncton, New Brunswick	4 000
Navajo Metals, division of General Scrap & Car Shredder Ltd.	Calgary, Alberta	3 000
Stelco Inc.	Edmonton, Alberta	8 000
Richmond Steel Recycling Limited	Richmond, British Columbia	5 800
General Scrap & Car Shredder Ltd.	Winnipeg, Manitoba	3 000
Total		85 100

TABLE 8. WORLD RAW STEEL PRODUCTION, 1987 AND 1988

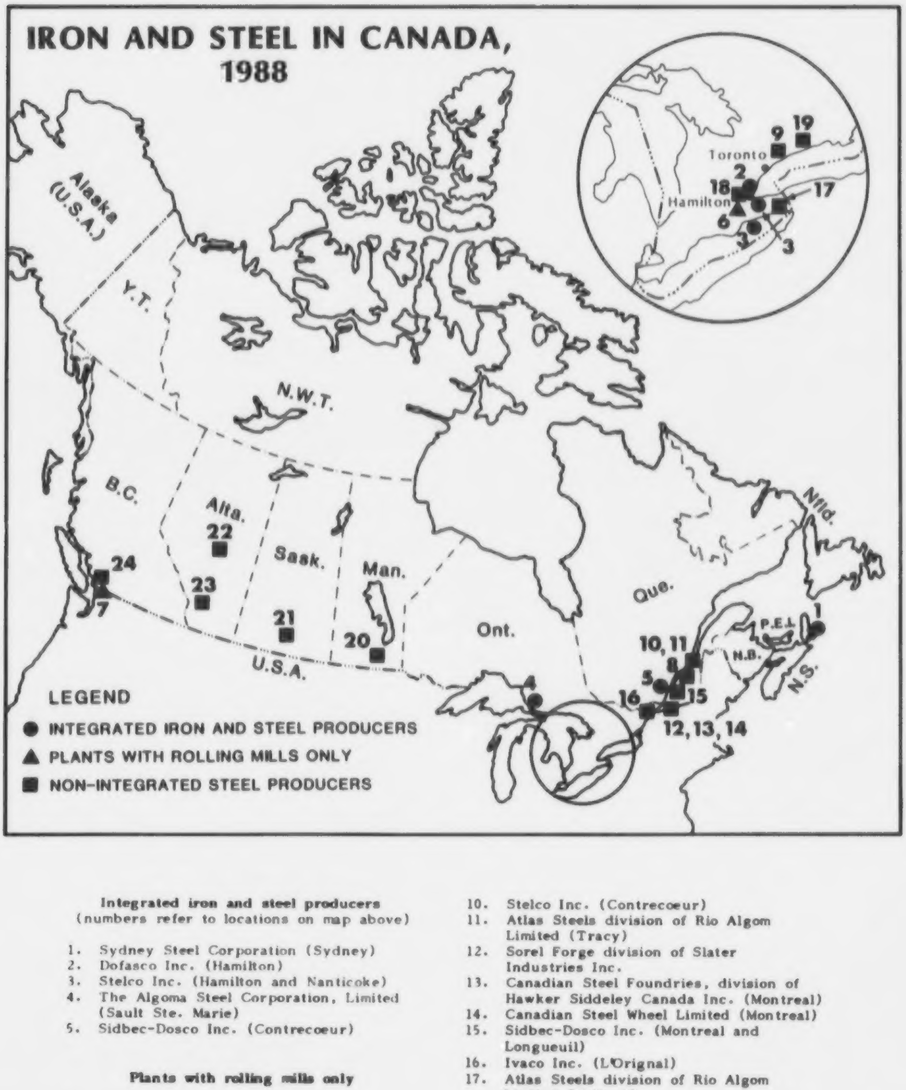
	1987^r	1988^e
	(million tonnes)	
U.S.S.R.	161.4	163.7
Japan	98.5	105.7
United States	81.0	90.8
People's Rep. of China	56.0	59.0
F.R. of Germany	36.2	41.0
Italy	22.8	23.7
Brazil	22.2	24.6
France	17.7	19.0
Poland	17.1	17.0
Czechoslovakia	15.4	15.4
United Kingdom	17.4	18.6
Republic of Korea	16.8	19.1
Romania	15.0	15.0
Spain	11.8	11.7
Canada	14.7	14.9
India	13.1	14.2
Belgium	9.8	11.2
DPR Korea	9.5	6.8
South Africa	8.7	8.8
East Germany	8.2	8.3
Mexico	7.5	7.8
Australia	6.1	6.3
Taiwan	5.8	8.3
Netherlands	5.1	5.5
Turkey	7.0	8.0
Austria	4.3	4.6
Sweden	4.6	4.8
Yugoslavia	4.4	4.5
Hungary	3.6	3.5
Venezuela	3.7	3.6
Luxembourg	3.3	3.7
Argentina	3.6	3.6
Finland	2.7	2.8
Bulgaria	3.0	3.0
Others	19.2	20.7
Total	735.9	780.0

Source: International Iron and Steel Institute.
^e Estimate; ^r Revised.
Note: Totals may not add due to rounding.

TABLE 9. CAPACITY AND PRODUCTION OF DIRECT REDUCED IRON (DRI), 1987

Country	Capacity (Mt/y)	Production (Mt)
Argentina	0.93	1.04
Brazil	0.32	0.20
Burma	0.04	0.02
Canada	1.00	0.73
Egypt	0.72	0.47
India	0.30	0.19
Indonesia	2.30	1.03
Iran	0.73	0.00
Iraq	0.49	0.00
Malaysia	1.32	0.59
Mexico	2.03	1.56
New Zealand	0.17	0.00
Nigeria	1.02	0.14
Peru	0.10	0.06
Qatar	0.40	0.47
Saudi Arabia	1.11	1.04
South Africa	0.80	0.84
Sweden	0.00	0.00
Trinidad and Tobago	0.84	0.49
United Kingdom	0.80	0.00
United States	0.40	0.21
U.S.S.R.	1.67	1.26
Venezuela	4.50	3.12
West Germany	0.40	0.20
Total	22.39	13.66

Source: Midrex Corp., North Carolina, United States.



IRON AND STEEL IN CANADA, 1988

Alaska (U.S.A.)
Y.T.
N.W.T.
B.C.
Alta.
Sask.
Man.
Ont.
Que.
Nfld.
P.E.I.
N.B.
N.S.
U.S.A.
Toronto
Hamilton
1
2
3
4
5
6
7
8
9
10,11
12,13,14
15
16
17
18
19
20
21
22
23
24
LEGEND
● INTEGRATED IRON AND STEEL PRODUCERS
▲ PLANTS WITH ROLLING MILLS ONLY
■ NON-INTEGRATED STEEL PRODUCERS

Integrated iron and steel producers
(numbers refer to locations on map above)

1. Sydney Steel Corporation (Sydney)
2. Dofasco Inc. (Hamilton)
3. Stelco Inc. (Hamilton and Nanticoke)
4. The Algoma Steel Corporation, Limited (Sault Ste. Marie)
5. Sidbec-Dosco Inc. (Contrecoeur)

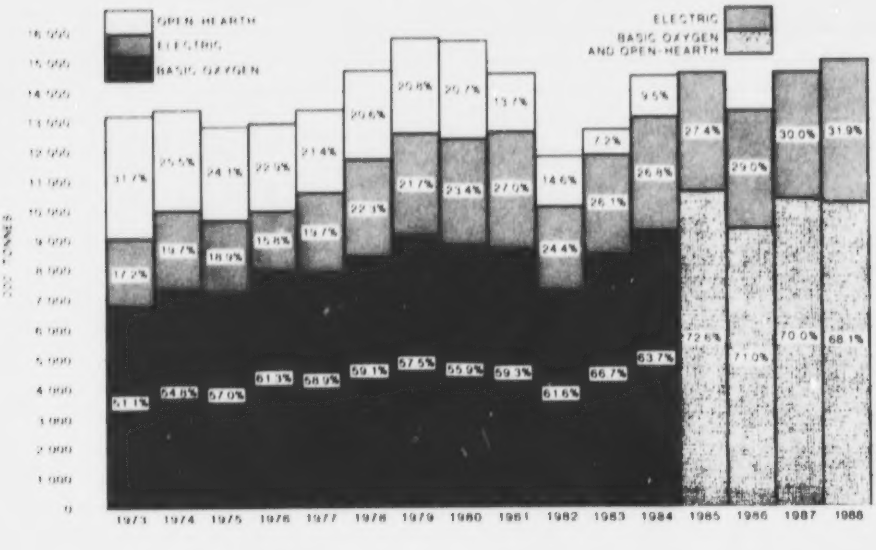
Plants with rolling mills only

6. Stanley Strip Steel division of Canada Inc. (Hamilton)
7. Pacific Continuous Steel Limited (Delta)

Non-integrated steel producers

8. QIT-Fer et Titane Inc. (Sorel)
9. Courtice Steel Limited (Cambridge)
10. Stelco Inc. (Contrecoeur)
11. Atlas Steels division of Rio Algom Limited (Tracy)
12. Sorel Forge division of Slater Industries Inc.
13. Canadian Steel Foundries, division of Hawker Siddeley Canada Inc. (Montreal)
14. Canadian Steel Wheel Limited (Montreal)
15. Sidbec-Dosco Inc. (Montreal and Longueuil)
16. Ivaco Inc. (L'Orignal)
17. Atlas Steels division of Rio Algom Limited (Welland)
18. Hamilton Specialty Bar division of Slater Industries Inc.
19. Co-Steel Inc. (Whitby)
20. Manitoba Rolling Mills division of the Canam Manac Group Inc.
21. IPSCO Inc. (Regina)
22. Stelco Inc. (Edmonton)
23. Western Canada Steel Limited (Calgary)
24. Western Canada Steel Limited (Vancouver)

CANADA, PRODUCTION OF STEEL BY FURNACE TYPE



Salt

M. PRUD'HOMME

SUMMARY

Canada produces rock salt from four underground mines and as by-product from two potash mines. Rock salt accounts for 67% of total salt shipments. Brine is also produced in 11 plants for the manufacture of evaporated salt and chloralkalies.

In 1988, Canadian production of salt rose 9% to 11.05 Mt due to high operating levels, particularly in New Brunswick, Ontario and Quebec. Shipments of all types of salt increased 8% to 10.97 Mt of which 63% was from Ontario. The average unit value of salt rose 2.5% to $23.46/t. Rock salt deicing markets remained light while sales of evaporated salt products were stable as demand for chloralkali used in pulp and paper and polyvinyl chloride products continued to be strong.

During 1988, The Canadian Salt Company Limited continued underground work at Pugwash, Nova Scotia, for the development of a new 300 m mining level due for completion by 1990. A new brine evaporator was commissioned, improving recovery. In April, The Canadian Salt Company Limited purchased for $35 million the assets of Seleine Mines Inc. located on Îles-de-la-Madeleine. The new owner is committed to invest close to $16 million over the next five years to modernize the operations and raise annual production capacity by 20% to 1.5 Mt. The supply contract with the Quebec Ministry of Transportation was extended six years to 1998. During 1988, Seleine Mines Inc. undertook the expansion of surface storage at the mine site and carried out studies for developing new mining stopes at the 273 m level. In Ontario, Domtar Chemicals Group, division of Domtar Inc. continued the construction of a new $10 million underground mill at Goderich; the mill is expected to be commissioned early in 1989. At Sarnia, unionized workers at Dow Chemical Canada Inc. ended a seven-month strike in late November with a two year contract; disruptions of operations were minimal. The Canadian Salt Company Limited started the development of new mining faces in the northwest area of its lease in Windsor, Ontario; it commissioned a new superheater at its Lindberg evaporated salt operation in Alberta.

During 1988, several agencies in Ontario pursued studies and field tests to compare the performance of salt with that of certain promising substitutes, such as Calcium-Magnesium Acetate (CMA) and Sodium Formate (NaFo). CMA proved to have an effectiveness comparable to that of salt but remained available only in limited quantities and at a very high cost, up to 35 times that of salt. New salt deicing products containing corrosion inhibitors were developed for use in areas with reinforced concrete and sidewalk pavements.

On a nine-month basis, salt imports amounted to 926 000 t, a 2% decline over 1987. Salt was mainly imported from the United States (63%) and Mexico (23%) into British Columbia (43%), Ontario (29%) and Quebec (18%). Exports rose drastically by 54% to 2.02 Mt and were mostly to the United States from Ontario (66%), Quebec (17%) and Nova Scotia (4%).

Canadian rock salt prices increased by 5-7% in 1988, ranging between $41 and $70/t for deicing rock salt in bulk shipments, f.o.b. works in various locations in Canada.

Demand for salt will continue to be associated with a mature deicing market and a stabilizing consumption in chloralkali. The latter sector is expected to remain strong for the next few years as consumption of chloralkali is expected to grow at a rate of 2.0% up to 1991 in North America due to the sustained performance of the pulp and paper, polyvinyl chloride and alumina industries.

M. Prud'homme is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 992-3258.

DOMESTIC PRODUCTION AND DEVELOPMENTS

In 1988, Canadian production of salt was estimated at 11.05 Mt, a 9% increase over 1987. Strong growth occurred in New Brunswick where production rose 19%, and in Ontario and Quebec as well. Shipments of all types of salt increased 8% to 10.97 Mt of which 63% was from Ontario. The average unit value of salt rose 2.5% to $23.46/t.

The rock salt deicing market continued to remain light due to a combination of fair weather in 1987, stock accumulation and environmental concerns. Sales of evaporated salt were stable as growth in consumption for chloralkali was maintained by stronger demand for sodium chlorate and caustic soda offsetting the decline in chlorine. The growing usage of sodium chlorate in pulp and paper has contributed to lower demand for chlorine which resulted in a severe shortage of its by-product, caustic soda. In 1988, demand for pulp and paper chemicals remained strong in Canada; pulp mills operated at 97% of capacity and production of pulp and paper products grew 3% over 1987. The chloralkali industry has been running at close to effective capacity rates.

Despite lower demand for chlorine in pulp and paper, consumption remained strong in the manufacture of polyvinyl chloride.

Atlantic region. Salt deposits occur in isolated sub-basins of a large sedimentary basin that underlies the northern mainland of Nova Scotia and extends westward under the bordering areas of New Brunswick, northeastward under Cape Breton Island, Prince Edward Island, Îles-de-la-Madeleine and southwestern Newfoundland. The salt beds occur within the Mississippian Windsor Group and are generally folded and faulted. The deposits appear to be steeply dipping tabular bodies, domes and brecciated structures of rock salt.

Salt production in the Atlantic Provinces is from an underground rock salt mine at Pugwash, Nova Scotia, an underground potash and salt mine at Sussex, New Brunswick and a brining operation near Nappan, Nova Scotia.

In New Brunswick, Potash Company of America, Inc. (now amalagamated into Rio Algom Limited) produces potash and by-product salt at its underground mine near Sussex. Salt is extracted at a rate of 400 000 to 500 000 t/y and is sold mainly to the eastern United States. Reserves are estimated to be large enough to operate for as long as potash is extracted which is for at least 20 years. Salt is marketed for road de-icing and chemical plants. The salt grades were marketed under a sales contract to The International Salt Company of New York through Iroquois Salt Products Ltd., its Canadian subsidiary.

Denison-Potacan Potash Company (DPPC) produced small amounts of salt from its potash mine now under development at Salt Springs near Sussex. Salt grades are marketed locally.

In Nova Scotia, The Canadian Salt Company Limited operates an underground rock salt mine at Pugwash in Cumberland County, with a rated capacity of approximately 1.2 Mt/y. Most of the salt from this mine is used for snow and ice control. In the evaporated salt plant, saturated brine is fed to a quadruple effect vacuum pan, rated at 13 t/h, where brine solution is evaporated to produce high quality salt crystals for use in the chemical and food industries. In 1988, development work continued at the 300 m mining level; it is due for completion in 1990. Work on the ramp and sublevel 276 m is expected to be completed in 1989. A new brine evaporator was commissioned in mid-November; although overall capacity remains the same, the new vacuum pan has improved efficiency. The company plans to replace the three old evaporators remaining.

Domtar Chemicals Group, division of Domtar Inc. has a brining operation at Nappan in Cumberland County. Evaporated salt products are used for table salt, fisheries and water conditioning.

Quebec. A salt deposit located on the Archipelago of Îles-de-la-Madeleine, in the Gulf of St. Lawrence, is part of the Mississippian Carboniferous Basin. Discovered in 1972, the Rocher-aux-Dauphins deposit is characterized by thick sequences of commercial salt, large sequences of rythmic salt and anhydrite cycles, abundance of low-grade potash horizons and some clay. The deposit is a typical piercement salt diapir generated by upward movements of the salt from the underlying anticlinal structure. It contains about 4 billion t of raw salt of which a quarter exceeds 97% sodium chloride. The salt lies between 30 m and 75 m underneath the surface. Reserves are 460 Mt of which 34.2% are mineable at an average grade of 94.5% NaCl.

In April 1988, the assets of Seleine Mines Inc. (a former subsidiary of the Société québécoise d'exploration minière) were purchased by The Canadian Salt Company Limited for $35 million. The move to privatize the salt mine was initiated by the Quebec government in November 1987. The Canadian Salt Company Limited will invest close to $16 million over five years to modernize the operations and to expand annual production capacity from 1.25 Mt to 1.50 Mt. The company has agreed to keep the mine in operation for at least ten years, to maintain the proportion of employees originating from the Islands and to keep Seleine Mines Inc.'s head office in the Province of Quebec. The supply contract between Seleine Mines Inc. and the Quebec Ministry of Transportation has been extended six years to 1998.

During 1988, the company started the expansion of surface storage at the mine site, and carried out studies for developing new mining stopes at the 273 m level; mineable reserves at the 223 m level are expected to be depleted by 1990. Modifications of the underground mill were completed and resulted in better grade control. A new salt storage facility was constructed in Trois-Rivieres, Quebec.

Ontario. Thick salt beds underlie much of southwestern Ontario, extending from Amherstburg northeastward to London and Kincardine, bordering on what is known geologically as the Michigan Basin. As many as six salt beds, occurring in the Upper Silurian Salina Formation at depths from 275 to 825 m, have been identified and traced from drilling records. Maximum bed thickness is 90 m, with aggregate thickness reaching as much as 215 m. The beds are relatively flat-lying and undisturbed, resulting in low-cost mining.

During 1988, production was from two rock salt mines (Goderich and Ojibway) and brining operations at Goderich, Sarnia, Windsor and Amherstburg.

At Goderich, Domtar Chemicals Group operates an underground rock salt mine. In 1988, the construction of a new underground mill continued. The $10 million project is expected to be completed in early 1989; the mill will be commissioned during the first quarter of 1989. Access to development areas where cave-ins occurred in 1987 has been completely restored. The Mining Research Laboratories of CANMET (Canada Centre for Mineral and Energy Technology) and Domtar Chemicals Group have agreed on a three-year joint project to install an innovative remote system to monitor underground methane gas levels and to control mine air quality. Domtar's salt is marketed mainly for ice control and it is sold mainly in eastern Canada, in the north central United States, and in regions accessible through the Mississippi River system. Evaporated salt is also produced at the Domtar brining operation located near Goderich.

At Sarnia, Dow Chemical Canada Inc. produces brines from wells for the production of caustic soda and chlorine. In 1988, over 750 unionized workers were on strike for a seven-month period ending in late November upon which an agreement for a two-year contract was signed. The plant continued to operate and meet customer requirements.

The Canadian Salt Company Limited produces both rock salt from the Ojibway underground mine and vacuum salt products from brine wells near Windsor. The total rated capacity for rock salt exceeds 2.5 Mt/y. Rock salt is extracted from a depth of 297 m while brine is pumped from 427 m and 457 m. In 1988, the company undertook development work to increase the number of mining faces in the northwest area of its lease. Further extensions were also being planned in the southwest area.

In the vicinity of Amherstburg, General Chemical, a division of General Chemical Canada Ltd., operates a brining operation for the manufacture of sodium carbonate and by-product calcium chloride.

Prairie Provinces. Salt beds underlie a broad belt of the Prairie Provinces extending from the extreme southwestern corner of Manitoba, northwestward across Saskatchewan and into the north-central part of Alberta. Most of the salt deposits occur within the Prairie Evaporite Formation, which constitutes the upper part of the Middle Devonian Elk Point Group, with thinner beds of salt occurring in Upper Devonian rocks. Depths range from 180 m at Fort McMurray, Alberta, to 900 m in eastern Alberta, central Saskatchewan and southwestern Manitoba, and to 1 830 m around Edmonton, Alberta, and in southern Saskatchewan. Cumulative thicknesses reach a maximum of 400 m in east-central Alberta. The beds lie relatively flat and undisturbed. The same rock sequence contains a number of potash beds currently under exploitation in Saskatchewan.

In Saskatchewan, four companies produce salt from the Middle Devonian Prairies formation. International Minerals & Chemical Corporation (Canada) Limited (IMCC) supplies by-product rock salt from its potash operation at Esterhazy. Its salt is distributed locally for road de-icing. Domtar Inc. operates a brining operation, near Unity, for the production of fine vacuum pan salt; Unity has the sole fused salt facility operating in Canada as other salt operations switched to salt pelletizing through compaction. The Canadian Salt Company Limited at Belle Plaine produces table salt from by-product brine from an adjacent potash solution mine operated by Kalium Chemicals and Saskatoon Chemicals, a division of Weyerhaeuser Canada Ltd., produces brines from wells near Saskatoon for the manufacture of caustic soda and chlorine, used mainly by pulp producers as a bleaching agent.

In Alberta, two producers operate brining operations: at Fort Saskatchewan near Edmonton, Dow Chemical Canada Inc. produces salt brine for the manufacture of chloralkali chemicals; and, at Lindberg, The Canadian Salt Company Limited produces fine vacuum pan salt. In 1988, the latter company commissioned a new superheater installed in late December 1987. The equipment will permit the company to dry superheated steam to prevent excessive wear on the Brown-Boveri turbo-generator.

British Columbia. There is no production of salt in this province where three companies operate six chloralkali plants; solar salt is imported from Mexico, the United States and Chile.

CONSUMPTION AND TRADE

Consumption. The 1987 consumption of salt in Canada was estimated at 7 503 800 t, an 8.7% decrease over 1986. The use of salt for snow and ice control continued to decline for the fourth year (13.4% from 1986) to 3.4 Mt; however, road deicing remained a major usage accounting for 45% of total consumption, while industrial chemicals accounted for 50%.

Worldwide, salt is largely used as a chemical raw material accounting for 60% of world consumption, followed by table salt (19%), and road deicing (11%); the remaining 10% was used in animal feed and water treatment. The consumption pattern differs in North America where the chemical industry consumes about half of total production, followed by highway usage and the food industry.

The industrial chemicals industry consumes salt for the manufacture of chloralkali such as caustic soda (sodium hydroxide), chlorine and sodium chlorate. Salt for four caustic soda and chlorine plants in Canada is obtained from on-site brining and natural brines; others use mined rock salt or imported solar-evaporated salt. Other industrial chemicals that require significant quantities of salt include sodium bicarbonate, sodium chlorite, sodium hypochlorite, and sodium carbonate (soda ash).

Consumption for snow and ice control varies from year to year, depending on weather conditions. For the past ten years, the average proportion for this purpose in Canada was about 45% of total consumption, compared with 24% for the United States and 14% for western Europe. On a world basis, this application accounts for 11% of total consumption.

The most widely used chemical deicers are sodium chloride (salt) and calcium chloride. Potassium chloride (potash) and urea are also used to some extent. However, the widespread uncontrolled use of deicing salt augments the risks of corrosion and environmental degradation. These concerns have led to research in the field of salt substitutes for snow and ice control. Mixtures of sand, calcium chloride and salt have been tested in some countries. Chemicals such as Calcium-Magnesium Acetate (CMA) and Sodium Formate (NaFo) have been tested.

During the winters of 1986-87 and 1987-88, field studies were undertaken by the Ontario Ministry of Transportation and by the City of Ottawa to compare the performance of CMA and rock salt as de-icing chemicals. CMA was found to have a comparable effectiveness to salt and was relatively more effective in long storms. Application rates for CMA ranged between 1.2 and 1.7 times that for salt, but the numbers of application for each product differed since CMA has a residual effect from one storm to the next. However, CMA is only available in limited quantities and at very high cost, up to 35 times that of salt. NaFo has also been tested by the City of Ottawa with promising results but it costs 17 times as much as salt.

Since mid-1987, the Road and Transportation Association of Canada (RTAC) has been coordinating an extensive project for evaluating degradation of highways and related infrastructures. The Canada - Strategic Highways Research Program (C-SHRP) is a $5 million project funded by provincial and federal grants over a 5-year period. The program complements the American SHRP project. It has four elements: monitoring, technology transfer, integrated and complementary research programs both linked to the U.S.-SHRP program. The C-SHRP program encompasses special research on pavements, structures, and snow and ice control. In 1988, research was undertaken to evaluate the effectiveness of de-icers in pavement bond prevention, disbonding and surface modification; to develop improved sodium chloride de-icers; and to establish evaluation procedures for de-icing chemicals. Experimental work was also carried out on concrete protection and rehabilitation from chemical and physical degradation.

During 1988, a Canadian salt producer introduced a new salt product for use as a de-icing agent which contains a corrosion inhibitor. The salt mixture is described as an effective de-icer cheaper than Calcium-Magnesium Acetate. The inhibitor is reported to be safe and capable of penetrating concrete. The new de-icer can minimize corrosion in new structures as well as in corroding chloride-contaminated reinforced concrete. It reportedly can reduce corrosion by up to four times compared to rock salt used alone.

Another salt producer developed a new salt product for the retail market, called Sidewalk Saver. The chemically treated salt retards corrosion on concrete; it will be available to consumers next year.

The adverse effects of salt have been recognized by the Salt Institute of Washington which distributes information on salt damages to highways, streets and infrastructures, on proper storage and spreading methods.

Other sectors that consume salt include the food industry, animal diet, fishery industry and water treatment which together account for less than 10% of total Canadian consumption. Over the last few years, low salt diets have become a popular response to perceived health risks associated with salt consumption but more recent studies on the effects of salt have challenged that view. Meanwhile, the salt industry reacted by developing salt mixtures containing both potassium and sodium chlorides resulting in lower sodium intake.

Chlorine, a major market for salt, is currently under investigation as the principal pulp bleaching agent responsible for the presence of 2, 3, 7, 8-TCDD (tetrachlorodibenzo-p-dioxin) in certain pulp and paper mills in North America. Dioxins have been identified as potential promotors or initiators of cancer. The Pulp and Paper Research Institute of Canada at Pointe Claire, Quebec, is carrying out studies on the formation and the elimination of these chemicals. Current options to avoid the formation of dioxins are being examined, such as switching to unbleached paper or using sodium chlorate bleaching technology.

TRADE

In 1987, salt imports reached 1.1 Mt; the average unit value for imported salt rose 2% to $21.48/t. Exports dropped 23% to 1.9 Mt valued at $33.4 million. On a nine month basis, 1988 imports amounted to 926 000 t, a 2% decline compared to the same period in 1987. Salt was mainly imported from the United States (63%) and Mexico (23%) into British Columbia (43%), Ontario (29%), and Quebec (18%). In 1988 exports rose drastically by 54% to 2 021 000 t. Exports were mostly shipped to the United States from Ontario (66%), Quebec (17%) and Nova Scotia (4%).

WORLD PRODUCTION AND REVIEW

In 1987, world production remained stable at 177.6 Mt. Salt is produced in about 200 countries which are mostly self-sufficient for their domestic requirements. The United States was the largest producer accounting for 18.5% followed by China (11%), the U.S.S.R. (9%) and West Germany (7%). Canada is the sixth largest producer with 6% of world production after India as the fifth producer with close to 11 Mt/y.

United States. In 1988, salt production rose 2% to 34.3 Mt, valued at US$660 million. Thirty-two companies operated 68 plants in 15 states. Apparent consumption reached 38.5 Mt, a 2% drop from 1987. Brines accounted for 49% of salt sold or used, followed by rock salt (33%), vacuum pan (11%) and solar salt (7%). Imports remained stable at around 5.2 Mt and were mainly from Canada, Mexico and the Bahamas. Exports increased 37% to 680 000 t, and were mainly to Canada.

Half of the salt produced is used by the chemical industry for the manufacture of chloralkali. Salt for highway de-icing, accounted for about 25% of apparent consumption. There was strong demand from the chlorine and caustic soda industries as production of these chemicals rose 6% over 1987. The average unit value for rock salt declined 6% to US$12.24/t.

American Salt Company was sold for US$31 million to U.S. interests. The company is based in Kansas City (Missouri) and is the fourth largest producer in the United States with operations in Lyons (Kansas) and Grantsville (Utah).

The International Salt Company of Clarks Summit (Pennsylvania) was authorized by the U.S. Department of Justice to acquire the salt operations of Diamond Crystal Salt Company in St. Clair (Michigan). The US$60 million transaction involved operations in St. Clair and Manistee (Michigan), Akron (Ohio), Williston (North Dakota), and a solar salt facility near the Great Salt Lake (Utah).

Ohio Corp. announced the development of an underground salt cavity at its brine operation near McIntosh (Alabama). The resulting caverns will be used for a compressed air energy storage power plant expected to be completed by 1991.

INTERNATIONAL TRADE

Salt is a widespread, low value and bulk commodity. It is relatively easy to extract and transportation represents a significant proportion of the total delivered price of salt. As a result, international trade in salt is small relative to world production, i.e., about 20% of total world production. Major international routes consist of cross-border trade and trade within geographical areas. A report from Drewry Shipping Consultants Ltd. in 1986 indicated that international seaborne salt trade is expected to reach 18.7 Mt in 1991. Trade in the Pacific area will account for half of seaborne movements, followed by North America (24%) and northwestern Europe (20%). Australia is expected to remain the major supplier to Japan while Mexico will continue to export mainly to Japan and North America. The European Economic Community is forecast to remain essentially self-sufficient with very minor imports from non-members.

PRICE

Salt is not a standard commodity and its price range depends on factors such as production methods, purity, scale of operations and transportation costs.

In 1988, prices for deicing rock salt, bulk, f.o.b. works, rose 5-7% to between $41 and $70/t. Prices, f.o.b. works, in the Atlantic Provinces were around $41-43/t, in Quebec $57-70/t, and in Ontario $42-46/t. Agricultural salt products cost around $4-8 per 25 kg lick block in western Canada. Fine evaporated salt prices increased 9% and varied between $94 and $128/t. Fishery grades were sold for $95-110/t, a 5% increase over 1987; prices for water conditioning grades ranged between $7-9 per 40 kg bag.

OUTLOOK

Canada is self-sufficient in salt; while eastern Canadian requirements of rock salt are served locally, some imports in western Canada serve the needs of chloralkali plants in British Columbia. Current capacity is sufficient to meet forecast growth in demand over the next decade.

The market for deicing salt within North America is maturing and will continue to face mounting pressures due to environmental concerns and infrastructure degradation. Field tests and new salt products may result in new opportunities for growth.

The manufacture of inorganic chemicals remains a promising market with sustained demand for salt in North America. The strong performance of the pulp and paper industry over the next few years is expected to spur demand for chloralkali such as caustic soda, sodium chlorate, and to some extent chlorine although environmental concerns over dioxins may accelerate the trend towards substitution.

Demand for sodium chlorate is expected to grow at a rate of 4% a year for the next three years as it penetrates bleaching markets. The sodium chlorate industry has announced several major expansions in Canada as it is operating at full capacity; these would raise total nameplate capacity 39% by 1991. Demand for chlorine is forecast to grow at a rate of 1-1.5%/y up to 1991 resulting from the anticipated strong performance of the polyvinyl chloride (PVC), vinyl chloride monomer (VCM), titanium dioxide and propylene oxide industries; however, the chlorine market will be affected by environmental pressures against the use of chlorofluorocarbons as refrigerants and blowing agents, and of chlorine as a pulp bleaching agent. The market for caustic soda is expected to continue to be tight in 1989 with estimated growth ranging between 2.0-2.4%/y up to 1991. The prolonged tightness in the supply of caustic soda may lead to some substitution with sodium carbonate (soda ash) and even lime.

TARIFFS

		Canada			United States
Item No.	Description	MFN	GPT	USA	Canada
2501.00	Salt (including table salt and denatured salt) and pure sodium chloride, whether or not in aqueous solution; sea salt				
2501.00.10	--- Table salt made by admixture of other ingredients when containing 90% or more of pure sodium chloride	4%	2.5%	Free	Free
2501.00.90	--- Other	Free	Free	Free	Free

Sources: Customs Tariffs, effective January 1989, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of United States (First Edition Supplement 2) effective January 1, 1989.

TABLE 1A. CANADA, SALT SHIPMENTS AND TRADE, 1986-87

	1986		1987	
	(tonnes)	($000)	(tonnes)	($000)
Shipments				
By type				
Mined rock salt	6 867 287	149 250	6 670 863	138 195
Fine vacuum salt	815 044	74 471	866 475	79 639
Salt content of brines used or shipped	2 649 515	15 745	2 591 715	20 792
Total	10 331 846	239 466	10 129 053	238 626
By province				
Nova Scotia	x	x	x	x
New Brunswick	x	x	x	x
Quebec	x	x	x	x
Ontario	6 240 440	147 523	5 690 381	139 326
Saskatchewan	473 316	25 759	460 212	26 177
Alberta	1 303 879	14 216	1 191 268	17 385
Total	10 331 846	239 466	10 129 053	238 626
Imports				
Salt, wet in bulk				
Mexico	288 826	3 779	340 794	4 175
United States	18 843	293	42 607	629
Other	0	0	72	1
Total	307 669	4 072	383 473	4 805
Salt, domestic				
United States	10 925	1 970	33 107	2 067
Switzerland	220	37	14	37
Netherlands	53	26	169	32
Other countries	152	33	123	30
Total	11 350	2 066	33 413	2 166
Salt, n.e.s.				
United States	832 618	17 695	584 536	15 313
Spain	25 809	470	29 050	489
Chile	109 515	1 161	53 451	567
Bahamas	14 244	246	27 012	498
Other countries	27 030	388	1 167	50
Total	1 009 216	19 960	695 216	16 917
By province of clearance				
Newfoundland	39 621	739	38 943	712
Nova Scotia	3 506	59	17 141	279
New Brunswick	3 872	74	95	19
Quebec	304 406	4 979	126 327	2 402
Ontario	407 217	9 443	381 756	9 553
Manitoba	3 840	287	2 401	178
Saskatchewan	6 959	768	10 274	861
Alberta	7 220	549	7 755	514
British Columbia	551 594	9 200	527 410	9 368
Total	1 328 235	26 098	1 112 102	23 886
Exports				
Salt				
United States	2 494 978	35 798	1 918 463	32 814
Leeward-Windward Islands	1 548	162	1 052	114
Other countries	5 992	524	5 171	507
Total	2 502 518	36 484	1 924 686	33 435

Sources: Statistics Canada; Energy, Mines and Resources Canada.
x Confidential; n.e.s. Not elsewhere specified.
Note: Totals may not add up due to rounding.

TABLE 1B. CANADA, SALT SHIPMENTS AND TRADE, 1988P

	1988P	
	(tonnes)	($000)
Shipments		
By type		
Mined rock salt	7 461 850	160 537
Fine vacuum salt	752 100	79 583
Salt content of brines used or shipped	2 760 650	17 398
Total	10 974 600	257 518
By province		
Nova Scotia	x	x
New Brunswick	x	x
Quebec	x	x
Ontario	6 862 900	158 440
Saskatchewan	399 500	24 458
Alberta	1 218 400	17 504
Total	10 974 600	257 518
Imports	**(Jan.-Sept.)**	
2501.00 Salt[1]		
United States	579 193	12 753
Mexico	217 082	2 424
Chile	73 850	730
Spain	31 797	539
Bahamas	20 336	342
Other countries	3 671	154
Total	925 929	16 942
By province of clearance		
Newfoundland	40 141	677
Prince Edward Island	12 000	205
New Brunswick	399	12
Quebec	167 248	1 851
Ontario	265 950	6 757
Manitoba	9 633	265
Saskatchewan	22 477	666
Alberta	11 346	381
British Columbia	396 735	6 128
Total	925 929	16 942
Exports		
2501.00 Salt[1]		
United States	2 021 022	29 612
St. Pierre and Miquelon	771	45
Puerto Rico	465	77
Other countries	1 480	190
Total	2 023 738	29 924

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Includes table salt, pure sodium chloride and seawater salt.

P Preliminary; x Confidential.

TABLE 2. CANADA, SUMMARY OF SALT PRODUCING AND BRINING OPERATIONS, 1986 AND 1987

Company	Location (Initial Production)	Annual Production Capacity	Production[1] 1987P (1986)	Employment 1987P (1986)	Remarks
		(000 tonnes)			
Nova Scotia					
The Canadian Salt Company Limited	Pugwash (1959)	1 200	925.0 (803.2)	184[2] (184)	Rock salt mining to a depth of 253 m.
	Pugwash (1962)	110	84.1 (77.7)		Dissolving rock salt fines for vacuum pan evaporation.
Domtar Inc.	Nappan (1947)	100	95.4 (68.6)	80 (81)	Brining for vacuum pan evaporation.
New Brunswick					
Potash Company of America, Inc.	Sussex (1980)	450	385.1 (480.5)	32[3] (32)	By-product rock salt from potash mine for use in snow and ice control.
Quebec					
Seleine Mines Inc.	Îles-de-la-Madeleine (1982)	1 200	1 099.7 (1 070.0)	203 (203)	Rock salt mining to a depth of up to 273 m.
Ontario					
General Chemical Canada Ltd.	Amherstburg (1919)	720	717.0 (670.0)	8[3] (8)	Brining to produce sodium carbonate.
The Canadian Salt Company Limited	Ojibway (1955)	2 500	1 702.4 (2 341.0)	215 (215)	Rock salt mining at a depth of 300 m.
	Windsor (1892)	150	137.5 (131.8)	90 (115)	Brining, vacuum pan evaporation.
Domtar Inc.	Goderich (1959)	2 800	2 410.8 (2 578.0)	335 (335)	Rock salt mining at a depth of 536 m.
	Goderich (1880)	120	108.9 (97.9)	70 (70)	Brining for vacuum pan evaporation.
Dow Chemical Canada Inc.	Sarnia (1950)	830	829.8 (776.1)	4[3] (4)	Brining to produce caustic soda and chlorine.

Prairie Provinces

International Minerals & Chemical Corporation (Canada) Limited	Esterhazy, Sask. (1962)	120	105.2 (114.9)	3 (3)	By-product rock salt from potash mine for use in snow and ice control.
The Canadian Salt Company Limited	Belle Plaine, Sask. (1969)	170	116.7 (117.9)	30 (30)	Producing fine salt from by-product brine from nearby potash operation.
Domtar Inc.	Unity, Sask. (1949)	180	157.3 (165.6)	85 (85)	Brining, vacuum pan evaporation, and fusion.
Saskatoon Chemicals	Saskatoon, Sask. (1968)	70	67.7 (66.7)	5[3] (5)	Brining to produce caustic soda, chlorine and sodium chlorate.
The Canadian Salt Company Limited	Lindbergh, Alta. (1968)	140	149.9 (137.4)	70 (70)	Brining, vacuum pan evaporation.
Dow Chemical Canada Inc.	Fort Sask., Alta. (1968)	1 400	1 083.4 (977.1)	3[3] (3)	Brining to produce caustic soda and chlorine.
		12 260	10 175.9 (10 674.4)	1 417 (1 442)	

Sources: Mineral Policy Sector, Energy, Mines and Resources Canada, 1988; Company surveys.

[1] Shipments. [2] Includes employment in brining operations at Pugwash. [3] Employment part of chemical complex.

P Preliminary.

TABLE 3. CANADA, SALT SHIPMENTS AND TRADE, 1980-88

	Producers' Shipments					
	Mined Rock	Fine Vacuum	In Brine and Recovered in Chemical Operations	Total	Imports	Exports
	(tonnes)					
1980	4 507 416	781 428	2 134 010	7 422 854	1 151 203	1 637 601
1981	4 371 314	764 037	2 107 243	7 242 594	1 254 992	1 507 710
1982	5 223 073	773 086	1 944 172	7 940 331	1 526 879	1 721 893
1983	5 846 994	714 464	2 040 925	8 602 383	814 250	1 914 629
1984	7 030 664	754 675	2 450 060	10 235 399	1 053 217	2 530 038
1985	6 608 739	805 209	2 670 749	10 084 697	1 255 518	2 263 076
1986	6 867 287	815 044	2 649 515	10 331 846	1 328 298	2 502 518
1987	6 670 863	866 475	2 591 715	10 129 053	1 112 102	1 924 686
1988P	7 461 850	752 100	2 760 650	10 974 600	..	..

Sources: Statistics Canada; Energy, Mines and Resources Canada.
P Preliminary; .. Not available.

TABLE 4. CANADA, AVAILABLE DATA ON SALT CONSUMPTION, 1984-87

	1984	1985	1986^{P}	1987^{e}
	(tonnes)			
Industrial chemicals[1]	3 586 487	3 870 616	3 966 364	3 775 000
Snow and ice control[2]	3 560 809	3 796 153	3 943 686	3 412 900
Fishing industry	58 000	68 684	59 960	70 500
Food processing				
Fruit and vegetable processing	18 269	18 776	19 084	18 000
Bakeries	11 947	11 313	10 995	11 000
Fish products	24 071	30 459	24 938	26 000
Dairy products	10 484	10 799	11 402	11 000
Biscuits	2 040	2 153	1 948	2 000
Miscellaneous food preparation	24 787	24 603	27 486	25 000
Grain mills[3]	64 254	66 730	64 355	65 000
Slaughtering and meat processors	29 557	30 646	29 672	29 000
Pulp and paper mills	30 048	35 327	38 206	34 000
Leather tanneries	7 948	6 617	9 851	8 000
Miscellaneous textiles	3 758	3 833[4]	4 871[4]	4 000[4]
Breweries	333	486	640	400
Other manufacturing industries	11 287	13 550	12 782	12 000
Total	7 444 079	7 990 745	8 226 240	7 503 800

Sources: Statistics Canada; Salt Institute; Energy, Mines and Resources Canada.
[1] Includes rock salt, fine vacuum salt and salt contained in brine. [2] Fiscal year ending June 30. [3] Includes feed and farm stock salt in block and base forms. [4] Estimated, data no longer available.
^{e} Estimated by Energy, Mines and Resources Canada; ^{P} Preliminary.

TABLE 5. CANADIAN CHEMICAL PLANTS USING SALT AS A MAJOR RAW MATERIAL, 1988

Company	Location	Parent Company	Plant Location	Type of Cells	Products	Capacity (tonnes)	Remarks
Alby Chlorate Canada Inc.	Valleyfield, Quebec	Alby Klorat AB, Sweden Olin Corp., U.S.A.	Valleyfield, Quebec	...	sodium chlorate	50 000	A two-phase expansion was announced in 1988: 25 000 t/y expansion to be completed by late 1989 while a second 25 000 t/y expansion is planned for 1990.
B.C. Chemicals Ltd.	Prince George, British Columbia	B.C. Chemicals Ltd., Prince George, B.C.	Prince George, British Columbia	...	sodium chlorate	33 000	Captive production.
Canadian Occidental Petroleum Ltd.	Calgary, Alberta	Occidental Petroleum Corporation, Los Angeles, CA U.S.A.	Amherstburg, Ontario	...	sodium chlorate	50 000	Bought from BCM Technologies Inc. in early 1988.
			Brandon, Manitoba	...	sodium chlorate	18 000	An expansion of 25 000 t/y is expected to come on stream by mid-1990.
			Nanaimo, British Columbia	...	sodium chlorate	8 000	An additional 8 000 t/y of sodium chlorate is planned by mid-1990.
				diaphragm	caustic soda chlorine	31 000 28 000	
			North Vancouver, British Columbia	diaphragm	caustic soda chlorine	155 000 141 000	
			Squamish, British Columbia	...	sodium chlorate	11 000	
			Squamish, British Columbia	mercury	caustic soda chlorine	75 000 68 000	
Canso Chemicals Limited	New Glasgow, Nova Scotia	C-I-L Inc., North York, Ontario	Abercrombie Point, Nova Scotia	mercury	caustic soda chlorine	20 000 18 000	
C-I-L Inc.	Willowdale, Ontario	Imperial Chemical Industries plc, England	Bécancour, Quebec	diaphragm	caustic soda chlorine	325 000 295 000	
			Cornwall, Ontario	mercury	caustic soda chlorine	38 500 35 000	
			Dalhousie, New Brunswick	mercury	caustic soda chlorine	31 000 28 000	

TABLE 5. (cont'd)

Company	Location	Parent Company	Plant Location	Type of Cells	Products	Capacity (tonnes)	Remarks
Dow Chemical Canada Inc.	Sarnia, Ontario	The Dow Chemical Company, Michigan, U.S.A.	Fort Saskatchewan, Alberta	diaphragm	caustic soda chlorine	524 000 476 000	
			Sarnia, Ontario	diaphragm	caustic soda chlorine	350 000 318 000	
ERCO Division of Tenneco Canada Inc.	Islington, Ontario	Tenneco, Inc., Texas, U.S.A.	Buckingham, Quebec	...	sodium chlorate	77 000	A further 50 000 t/y expansion in eastern Canada is under study.
			Thunder Bay, Ontario	...	sodium chlorate	68 000	Completion of a de-bottlenecking project in 1988, raising name-plate capacity by 2 000 t/y.
			North Vancouver, British Columbia	...	sodium chlorate	76 000	22 000 t/y expansion completed in the summer of 1988. Complete replacement of graphite cells is under study.
General Chemical Canada Ltd.	Amherstburg, Ontario	General Chemical Corporation, Morristown, New Jersey, U.S.A.	Amherstburg, Ontario	...	calcium chloride sodium carbonate	317 500 362 800	
Great Lakes Forest Products Limited	Thunder Bay, Ontario	Canadian Pacific Securities Limited Montreal, Quebec	Dryden, Ontario	membrane	caustic soda chlorine	16 000 14 500	
PPG Canada Inc. Industrial Chemical Division	Beauharnois, Quebec	PPG Industries, Inc. Pittsburg, Penn., U.S.A.	Beauharnois, Quebec	...	sodium chlorate	40 000	
				mercury	caustic soda chlorine	67 000 61 000	
QueNord Inc.	Magog, Quebec	Kema-Nobel AB, Sweden	Magog, Quebec	...	sodium chlorate	92 000	15 000 t/y expansion announced in 1988, due for completion in 1989.
St. Anne-Nackawic Pulp & Paper Co. Ltd.	Nackawic, New Brunswick	Parsons & Whittemore, Inc. New York, U.S.A.	Nackawic, New Brunswick	...	sodium chlorate	9 000	Captive production.
				membrane	caustic soda chlorine	10 000 9 000	Captive production.

Saskatoon Chemicals	Saskatoon, Saskatchewan	Weyerhaeuser Canada Ltd. Kamloops, B.C.	Saskatoon, Saskatchewan	...	sodium chlorate	25 000	The company announced a $17.8 million project to increase capacity to 44 000 t/y. Completion due late in 1989.
				membrane	caustic soda chlorine	36 000 33 000	

Sources: Mineral Policy Sector, Energy, Mines and Resources Canada; Chemicals Directorate, Department of Regional Industrial Expansion (Ottawa); December 1988.
... Not appropriate.

TABLE 6. WORLD SALT PRODUCTION, 1983-87

Countries	1983[r]	1984[r]	1985[r]	1986[P]	1987[e]
			(000 tonnes)		
United States	31 385	35 580	36 370	33 290	33 135
China[e]	16 125	16 280	14 440	17 300	19 960
U.S.S.R.[e]	16 200	16 510	16 100	16 050	16 050
West Germany	10 865	12 210	13 070	13 100	13 150
India	7 010	7 720	9 870	10 110	10 975
Canada	8 615	10 310	10 000	10 680	10 175
France	6 950	7 150	7 110	7 080	7 155
United Kingdom	6 310	7 130	7 140	7 070	7 075
Australia	5 170	5 700	6 170	6 170	6 170
Poland	3 625	4 710	4 860	5 420	6 165
Mexico	5 700	6 160	6 470	5 925	5 985
Romania	4 590	4 870	5 020	5 355	5 400
Italy	4 190	3 980	3 750	4 030	3 845
Other	32 100	34 160	33 355	35 380	32 360
Total	158 830	172 470	173 725	176 960	177 600

Sources: Energy, Mines and Resources Canada; U.S. Bureau of Mines, 1988.
P Preliminary; [e] Estimated; [r] Revised.

Silica

M.A. BOUCHER

SUMMARY

Preliminary figures indicate that in 1988 silica production shipments in Canada were 2 710 000 t; this compares with 2 661 903 t in 1987. Shipments increased mainly in Quebec, Manitoba and British Columbia, and decreased in Ontario and Newfoundland.

The flat glass and fiberglass markets which are related to the construction industry, performed well during the year. Also, consumption of foundry sand, and silica sand for use in the silicon carbide industry increased as the iron and steel and base metal industries fared better than in 1987.

However, the consumption of silica sand by the glass container industry, which is the largest consumer of high quality silica, continued to be affected negatively by the use of recycled glass waste and the use of lighter glass in vehicle construction. Competition from aluminum, paper and plastics also continued to erode markets traditionally belonging to glass containers.

CANADIAN SCENE

Newfoundland

All silica production from Dunville Mining Company Limited, a subsidiary of Tenneco Canada Inc. is captive to Tenneco, a producer of elemental phosphorus, where silica is used as a flux. The quartzite quarry at Villa Marie operates from May to December and produces silica grading close to 95% SiO_2. The ore is shipped to Tenneco's Long Harbour phosphorus plant.

Nova Scotia

Nova Scotia Sand and Gravel Limited produces a high purity silica from sand deposits, for a variety of uses such as sandblasting, glass, foundry sand, and frac sand. The mine is located near Shubenacadie.

New Brunswick

Chaleur Silica Ltd. produces silica for use as a flux in Brunswick Mining and Smelting Corporation Limited's Belledune lead smelter, for cement plants, and as sandblasting material.

Sussex Silica Inc. mines a high grade (+98% SiO_2) silica deposit near Sussex. The company produces lump silica and sand of various sizes. Lump silica and coarse-grained sand are used in the manufacture of silicon metal and silicon carbide in Quebec. The fine sand is used in sandblasting, as filter sand and decorative sand in the Maritimes, and as a flux for base metal smelters.

Quebec

Falconbridge Limited is the largest producer (in terms of volume and value of production) of silica east of Ontario. Silica is mined from a quartzite deposit at Saint Donat and from a sandstone deposit at Saint Canut. Silica from Saint Donat is refined at the Saint Canut plant near Montreal.

Most silica produced by Falconbridge originates from Saint Canut where the ore is crushed, screened and beneficiated by attrition scrubbing, flotation and magnetic separation. The company reported that it was expanding production capacity at its St. Canut operation from 500 000 t/y to 650 000 t/y. Capacity could be increased at low cost if markets expand. The major markets for Falconbridge products are the glass, fiberglass and silicon carbide industries.

Uniquartz Inc. mines a silica-rich sandstone deposit near St. Jean Vianney about 30 km from Matane. The deposit is reported to contain more than 25 Mt of high purity ore. Some 60 000 t/y of lump ore are sold to European consumers for the production of ferroalloys. A concentrator will soon be built for the production of higher purity silica. Eventually the company

---

M.A. Boucher is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 992-3074.

intends to produce some 200 000 t/y of high purity silica sand for use by the flat glass and foundry industries in Canada and western Europe.

Baskatong Quartz Inc. produces high-purity silica from a quartzite deposit north of Saint Urbain. The silica is used mainly by SKW Canada Inc. for the production of ferrosilicon and silicon metal. Baskatong also produces high-purity silica from quartz vein deposits located at Lac Bouchette south of Lac Saint-Jean. The silica is sold almost exclusively to SKW for the production of ferrosilicon.

Loma Enterprises Ltd. of Beauport crushes and classifies the fines produced by SKW Canada Inc. for sale to the silicon carbide and sandblast industries.

Armand Sicotte & Sons Limited mines Potsdam sandstone at Sainte Clothilde, south of Montreal. Lump silica is used for the production of ferrosilicon, phosphorus, and cement.

The Good Sand Company Ltd. mines silica sand and gravel at St. Joseph-du-Lac and at Ormstown. The material is used mainly for sandblasting but also for fiberglass and foundries.

During the year Multiver Ltée of Quebec, and Glaverbel SA of Belgium announced the construction of a 500 t/d flat glass plant to be built near Quebec City at a cost of $150 million. When production starts in early 1990 the plant is expected to consume approximately 100 000 t/y of silica.

As a direct result of strong competition from aluminum, paper and plastics, Consumers Packaging Inc. of Ville St-Pierre, Quebec, a producer of glass containers announced the indefinite closure of one of its two furnaces. The furnace consumed approximately 30 000 t/y of silica.

Ontario

Falconbridge Limited is also the largest producer (in terms of volume and value of production) of silica west of Quebec, with a reported total capacity of about 550 000 t/y. Lump quartzite from Badgeley Island, north of Georgian Bay is shipped by lake boat to Canadian destinations for the manufacture of ferrosilicon. The finer material produced by crushing, is shipped to Midland, south of Georgian Bay where it is further processed to a glass-grade silica sand, and silica flour for ceramic and other uses.

Manitoba

Marine Transport Limited of Selkirk, produces high-purity silica sand from a quarry on Black Island on Lake Winnipeg some 130 km north of Selkirk. The silica sand, mined from a poorly consolidated white sandstone, is well rounded and suitable for use in foundries, glass, fiberglass, construction, and as traction sand. The ore is washed, screened and dewatered at a plant on the island, and then shipped by barge to a processing plant at Selkirk on the Red River.

INCO Limited produces, from the Manasan quarry, a low-grade silica from an impure quartzite for its Thompson smelter and converter. Production varies from year to year depending on nickel production.

Saskatchewan

Hudson Bay Mining and Smelting Co., Limited (HBMS) produces smelter flux from two pits in the Amisk Lake area of northern Saskatchewan. The silica sand is used by Hudson Bay Mining at its Cu-Zn smelter in Flin Flon, Manitoba.

Alberta

Sil Silica, division of Clarepine Industries Inc., produces silica sand from local sand dunes in the Bruderheim area. Silica is sold mainly as fiberglass and sandblasting material. It is also sold as foundry sand, filtration sand, frac sand and as railway traction sand. Sil Silica has shown steady growth even during depressed economic conditions.

British Columbia

Mountain Minerals Co. Ltd. mines a high-purity, friable sandstone deposit near Golden. Rock is crushed, screened, washed, dried and separated into several sizes. These different sizes are sold for glass sand, sandblasting sand, foundry sand, filter media sand, golf course sand and fine sand.

TRADE

Most silica sand imported into Canada comes from loosely consolidated and easily processed sandstone or lake sand deposits located near the Great Lakes region of the United States in Illinois, Wisconsin, Michigan and Indiana. The imported silica sand is used mainly by iron and steel foundries and by the glass industry of Ontario and Quebec.

Imports of foundry sand dropped in 1987 because of stricter environmental controls and emphasis on recycling at foundries. Imports of silica sand for use by the glass industry declined because of stronger competition from Canadian producers.

OUTLOOK

Little improvement is expected in 1989 in Canada in the container glass industry. The flat glass and fiberglass industries should fare well as growth continues in the construction industry. In the long term, competition from U.S. producers of silica for glass and foundry sand will remain strong in Ontario and Quebec because of the proximity of these provinces to the low-cost producers of the United States Great Lakes region. Also due to the downsizing of passenger cars and recycling of silica sand at foundries, no growth can be expected in the foundry sand industry in Canada. Competition from substitutes for glass containers such as paper, plastics and aluminum will remain strong across Canada.

Sandblast will continue to decline as a result of tighter environmental controls and substitution. The filler market is still very small, but its growth will continue strong.

OPPORTUNITIES

Higher value silica products could be produced in Canada because of the low cost of electricity in certain parts of the country. Such products include:

a) cultured quartz
b) raw vitreous silica (MN.99.8% SiO_2) and manufactured products of vitreous silica (two fusion of silica are necessary for example to produce tubes and rods);
c) refined silicon carbide
d) monocrystalline silicon
e) high-purity ground silica (MN.99.5% SiO_2; 2 to 20 microns).

None of these products are yet manufactured in Canada.

Also there are potential opportunities for:

f) a new flat glass plant;
g) an integrated silicon carbide plant in western Canada, based on local raw materials and inexpensive electricity; and
h) a new reinforcement fiberglass plant.

PRICES

The unit value of shipments of silica in Canada was $17.34/t in 1988. This compares with $16.65 in 1987.

TABLE 1A. CANADA, SILICA PRODUCTION AND TRADE, 1986 AND 1987

	1986		1987	
	(tonnes)	($000)	(tonnes)	($000)
Production (shipments), quartz and silica sand				
Newfoundland	x	1 526	x	x
Nova Scotia	x	x	x	x
New Brunswick	x	x	x	x
Quebec	836 580	17 025	841 760	17 625
Ontario	1 029 506	10 716	1 013 704	11 467
Manitoba	x	x	x	x
Saskatchewan	128 400	x	163 166	x
Alberta	x	3 355	x	4 069
British Columbia	x	1 896	x	1 987
Total	2 640 436	41 640	2 661 903	44 317
Imports[1]				
Silica sand				
United States	1 055 209	20 200	836 367	16 492
West Germany	6	1	60	10
Total	1 055 215	20 201	836 427	16 502
Silex and crystallized quartz				
United States	318	270	368	355
Japan	30	44	-	-
Other countries	1	2	148	54
Total	349	316	516	409
Silica (including silica gel)				
United States	8 742	13 515	9 545	14 779
West Germany	1 049	3 142	699	2 657
Other countries	565	1 143	423	825
Total	10 356	17 800	10 667	18 261
Exports				
Quartzite				
United States	88 393	1 143	60 669	752
Total	88 393	1 143	60 669	752

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Includes sand for use in foundries and glass manufacturing, ground and flour sand, volatized and silica flue dust.

- Nil; x Confidential.

TABLE 1B. CANADA, SILICA PRODUCTION AND TRADE 1988P

		1988P	
		(tonnes)	($000)
Production (shipments)			
	Newfoundland	x	x
	Nova Scotia	x	x
	New Brunswick	x	x
	Quebec	895 000	19 212
	Ontario	925 000	10 425
	Manitoba	x	x
	Saskatchewan	169 000	x
	Alberta	x	5 300
	British Columbia	x	x
	Total	2 710 000	46 997
Imports[1]		(Jan.-Sept.)	
2505.10	Silica sands and quartz sands		
	United States	689 839	14 365
	West Germany	198	117
	Belgium	18	12
	Total	690 055	14 494
2506.10	Quartz (other than natural sands)		
	United States	6 277	364
	Brazil	42	2
	Total	6 319	366
2506.21	Quartzite crode or roughly trimmed		
	United States	617	81
	Total	617	81
2506.29	Quartzite n.e.s.		
	United States	896	84
	Brazil	161	4
	Total	1 057	88
2811.22	Silicon dioxide		
	United States	15 885	13 308
	West Germany	1 552	2 771
	Other countries	834	526
	Total	18 271	16 605
Exports			
2505.10	Silica sands and quartz sands		
	United States	7 930	267
	Other countries	201	103
	Total	8 131	370
2506.10	Quartz (other than natural sands)		
	United States	39 387	234
	Other countries	1 511	94
	Total	40 898	328
2506.29	Quartzite n.e.s.		
	United States	48 220	180
	Sweden	40	1
	Total	48 260	181
2811.22	Silicon dioxide		
	United States	151	73
	West Germany	143	39
	Other countries	62	45
	Total	356	157

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Includes sand for use in foundries and glass manufacturing, ground and flour sand, volatized and silica flue dust.

P Preliminary; x Confidential; n.e.s. Not elsewhere specified.

	Foundry		Glass Manufacturing	
	(tonnes)	($000)	(tonnes)	($000)
Newfoundland	-	-	-	-
Nova Scotia	1 354	24	-	-
Prince Edward Island	-	-	-	-
New Brunswick	174	2	-	-
Quebec	28 176	542	2 667	15
Ontario	380 584	4 918	170 531	2 017
Manitoba	611	83	-	-
Saskatchewan	120	14	-	-
Alberta	731	22	4	-
British Columbia	26 176	1 145	814	82
Total	437 926	6 760	174 016	2 114

Source: Statistics Canada.
- Nil.

TABLE 3. CANADA, SILICA PRODUCTION TRADE AND CONSUMPTION, 1970, 1975, AND 1980-87

	Production	Imports		Exports	Consumption[1]
Year	Quartz and Silica Sand	Silica Sand	Silex or Crystallized Quartz	Quartzite	Quartz and Silica Sand
			(tonnes)		
1970	2 937 498	1 176 199	186	58 917	3 979 305
1975	2 491 715	1 044 160	1 550	39 977	3 510 818
1980	2 252 000	1 200 237	281	63 166	3 326 956
1981	2 238 000	1 142 880	251	119 347	3 079 225
1982	1 797 000	788 768	241	65 333	2 400 549
1983	2 303 451	982 662	271	103 960	2 792 580
1984	2 658 932	1 076 082	494	116 283	3 145 308
1985	2 668 650	983 340	341	112 762	3 109 667
1986	2 640 436	1 055 215	349	88 393	2 954 085
1987	2 661 903	836 427	516	60 669	2 896 637

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Available data, as reported by consumers.

TABLE 4. TYPICAL BATCH FORMULATIONS FOR FLAT GLASS, GLASS CONTAINERS AND FIBERGLASS

Raw Materials	Percent by Weight	Source of
Flat glass[1]		
Silica sand	60	SiO_2
High calcium limestone	4	CaO
Dolomitic limestone	15	MgO and CaO
Soda ash	20	Na_2O
Salt cake or gypsum	0.5	Na_2O/CaO and SO_3
Rouge	0.5	Fe Colorant
Glass containers[2]		
Silica sand	60	SiO_2
Limestone	14-18	CaO, MgO
Soda ash	19	Na_2O
Alumina source (feldspar, nepheline syenite or aplite)	4-5	Al_2O_3, Na_2O, SiO_2
Others		
Gypsum and/or barite	1	SO_3/BaO
Fiberglass		
Insulating fiber[3]		
Silica	40	SiO_2
Soda ash	10	Na_2O
Feldspar or nepheline syenite	20	Al_2O_3, Na_2O, SiO_2
Borax or ulexite	15	B_2O_3
Dolomite or limestone	15	MgO, CaO
Reinforcing fiber[4]		
Silica	28-30	SiO_2
Boric acid	8-11	B_2O_3
Colemanite	11-17	CaO, B_2O_3
Kaolin	26-28	Al_2O_3, SiO_2
Limestone or dolomite	28-31	CaO, MgO
Soda ash	0-1	Na_2O

Sources: [1] LOF Glass Company, Toledo, Ohio. [2] Brockway Inc., Brockway, Pennsylvania. [3] Fiberglas Canada Inc. [4] PPG Canada Inc.

TABLE 5. FLAT GLASS AND CONTAINER GLASS MANUFACTURING PLANTS IN CANADA

Company	Plant Location	Type of Glass
PPG Canada Inc.	Owen Sound, Ontario	Flat
AFG Glass Inc.	Scarborough, Ontario	Flat
Domglas Inc.	Scoudouc, N.B.	Containers
	Montreal, Quebec	"
	Brampton, Ontario	"
	Hamilton, Ontario	"
	Redcliff, Alberta	"
Consumers Packaging Inc.	Montreal, Quebec	Containers
	Candiac, Quebec	"
	Etobicoke, Ontario	"
	Milton, Ontario	"
	Lavington, B.C.	"

TABLE 6. FIBERGLASS PLANTS IN CANADA

Company	Plant Location	Type of Fiber
Fiberglas Canada Inc.	Candiac, Quebec	Insulating
	Markham, Ontario	"
	Sarnia, Ontario	"
	Edmonton, Alberta	"
	Mission, B.C.	"
Manson Insulation Inc.	Brossard, Quebec	"
	Scarborough, Ontario	"
Manville Canada Inc.	Innisfail, Alberta	"
Graham Fiber Glass Limited	Erin, Ontario	"
Ottawa Fiber Inc.	Ottawa, Ontario	"
Fiberglas Canada Inc.	Guelph, Ontario	Reinforcing

Source: Falconbridge Limited.

TABLE 7. CANADA, REPORTED CONSUMPTION[1] OF SILICA, BY INDUSTRIES, 1986 AND 1987

	1986	1987P
	(tonnes)	
Primary glass and glass containers, and glass fibre wool and glass fibre	904 761	924 700
Nonferrous smelting and refining	801 600	729 715
Foundries	392 949	422 973
Chemicals	215 766	197 715
Artifical abrasives	119 366	120 516
Other products[2]	121 809	501 018
	2 954 085	2 896 637

---

[1] Available data as reported by consumers. [2] Includes asbestos products, asphalt roofing products, cement, ceramic products, structural clay products, cleansers, fertilizers, paint and varnish, pulp and paper and products, refractory brick, rubber products, ferro-alloys, primary steel and other miscellaneous products.
P Preliminary.

Silver

D. LAW-WEST

Production of silver from Canadian mines increased in 1988, to 1 527 t from 1 375 t in the previous year. However, the value of production was down substantially to $380 million compared to $424 million in 1987. This decrease reflects the drop in silver prices to US$6.51/oz. in 1988 from $7.02 in 1987.

Domestic production declined in Quebec, Ontario, Manitoba and Saskatchewan by a total of nearly 70 t but this was more than offset by increases of 110 t in the other provinces.

SUPPLY: CANADIAN DEVELOPMENTS

In the Atlantic provinces, by-product silver production from new gold mines partially accounted for the additional silver production. Nevertheless, base metal mines remained the most important source of silver. With silver output of 262 t, these provinces accounted for nearly 18% of total Canadian production compared with 14% in 1987.

Quebec's silver production dropped by 40 t to 110 t, or just over 7% of the country's total. The decline was due to reduced base metal production.

In Ontario, the largest silver producing province, output declined by 5% to 453 t in 1988. Again, much of this decline was due to reduced production of base metals.

Agnico-Eagle Mines Limited, the country's sole primary silver producer, operates three silver mines in the Cobalt area of northern Ontario. Ore from the Beaver-Temiskaming, Castle and Langis mines is trucked to the new 270 t/d mill where the silver is recovered using gravity and flotation methods. Refining is carried out at the company's refinery in Cobalt where nearly 1 million oz. was expected to be produced in 1988. Early in 1989, the company suspended mining operations due to low silver prices. The mill and refinery were expected to continue operating until mid-1989 at which time they would be shut down as well.

Silverside Resources Inc. along with its joint venture partner International Platinum Corporation are moving closer to a final production decision at the Helens-Eplett mine near Cobalt. The 55 t/d mill has been operated on a temporary basis and has attained 93% recovery. The ore at this operation is complicated by the presence of copper and arsenic.

In British Columbia, silver production increased by 10% to 449 t. Most of the additional supply is from gold mines entering production during the year.

Silver production in the two northern territories increased together by 6% to 188 t in 1988. The increase is the result of added output at both precious metal and base metal mines. However, silver production will decrease in 1989 due to closure of United Keno Hill Mines Limited at Elsa early in 1989. This facility will be kept on a standby basis in the short term pending an increase in silver prices.

The Royal Canadian Mint introduced the Silver Maple Leaf coin as part of its bullion coin program. The new coin is available only in a one ounce format. The selling price is based on the daily silver price plus a small handling charge. As with the other bullion coins, provincial sales taxes are added where applicable.

SUPPLY: WORLD DEVELOPMENTS

Estimated world silver production in 1988 rose by 4% to 14 150 t.

United States silver output has increased as the result of production at the many new gold mining operations opened during the year.

D. Law-West is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 992-4327.

United States Borax & Chemical Corporation announced that the Trinty mine near Lovelock, Nevada achieved silver production of 17 000 kg in September 1988, and totalled 46 655 kg for the third quarter of the year. The mine is a joint venture with Santa Fe Pacific Mining Inc. Heap leach production began in January 1988 and should continue to mid-1989.

American Silver Mining Co. plans to resume production at its mine in Idaho, where production was suspended in May 1986 because of low silver prices.

The first dore bar was poured at the Gilt Edge mine in South Dakota by MinVen Gold Corporation and its wholly owned operating company Brohm Mining Corporation. The operation is based on reserves of 6.1 Mt grading 1.43 g/t of gold in an oxide orebody with substantial additional sulphide ore. Annual production is expected to be 1 340 kg of gold and at least 1 870 kg of silver.

United States domestic supplies of silver from new production and scrap recovery increased by 12% in the first six months of 1988. The total amount available to the market was 2 130 t up from 1 850 t in the previous year.

Another chapter in the ongoing saga of the Hunt brothers' involvement in the silver industry ended when the Federal Jury ordered them to pay US$134 million in damages to the Peruvian mining company Minero Peru Comercial SA (MINPECO). The latter had sought US$150 million which it had claimed to have lost in 1979/80 when the brothers attempted to corner the silver market.

The Commodity Futures Trading Commission has also launched legal action against the Hunt brothers, claiming that they hoarded at least 100 million oz. and thereby driving the price up from less than US$11.00 to $50.35 during the six month period ending in March 1980. The price then crashed to $10.80, reportedly costing the brothers an estimated $1.3 billion. Several other lawsuits against the brothers are still outstanding.

In Peru, one of the world's largest silver producers, output was adversely affected by two labour strikes during the year. The first lasted for a month during the summer and reduced production at all but two of the fifteen largest silver producers. At that time the government declared force majeure on silver exports from state owned silver mines, which in the future would sell silver to the Central Bank. In addition, the Bank announced a silver purchase program at 15% above market prices to encourage private silver producers to sell to the bank. This special price, part of the government's longer term goal of building a silver fund that could be used as collateral for foreign purchases, ended in mid-September.

A second strike began on October 17th and lasted for fifty seven days. The striking miners demanded wage increases to compensate for monthly inflation which had reached a record 114% and which was expected to be well over 1000% for the year. On December 13th miners began to return to work following a negotiated settlement which called for better working conditions, minimum national wages with other wages negotiated on a mine by mine basis, and retirement benefit agreements.

The two strikes cost Peru at least $700 million in lost revenues from metal exports during the year. Silver production was expected to have fallen by over 10.6 million oz. (16%).

Mexico remained the largest silver producer with an estimated output of 2 400 t in 1988, compared with 2 270 t in the previous year.

CONSUMPTION AND USES

Photography continues as the cornerstone of world silver consumption, accounting for just over 51% of industrial uses. The silver is used as silver halide in forming the photographic images used in X-rays (31%), graphic arts (25%), amateur and professional photographers (30%), motion pictures (10%), and a variety of other types of photography.

The photographic industry responded to the price surge of 1979/80 by not only recycling silver but also by reducing the amount of silver on each negative by more than half, from 10 g/m^2 to 4 g. While photographic applications of silver have continued to grow, total consumption of silver has not yet recovered to levels prior to the price escalation.

The electrical and electronics industry is the second most important industrial user of silver, due to its high electrical and thermal conductivity, good corrosion resistance, and ductility. While consumption in this industry peaked in the early 1970s, potential new uses could substantially increase silver use. The automobile industry consumed over 1.2 t in 1987 for use in heated windshields. If this option becomes a standard feature, silver consumption would increase dramatically.

The jewellery and sterlingware industries never recovered from the drop in demand for silver products at the beginning of the decade. The latest figures indicate that silver usage in jewellery and sterlingware is still less than half the 2 831 t consumed in 1977. This is one market where consumption potentially could be increased through a well planned promotional campaign.

Silver used in coins increased to nearly 1 000 t in 1987, up nearly 20% from 1986. Many countries have issued bullion silver coins, such as the American Silver Eagle, which generally contain an ounce of silver. In late 1988, Canada joined these ranks. The Silver Maple Leaf coin was introduced in a one ounce format to complement the gold and platinum bullion coins. Early sales indicated that the coin is likely to be very popular.

MARKETS, PRICES AND STOCKS

Silver is traded on several exchanges around the world. The London market is the most important among those trading physical silver bullion. Each day the price of silver is fixed at the time when all purchase and sell orders have been balanced. The price is quoted in pounds sterling and U.S. dollars and generally serves as a reference price for the other physical markets around the world. The normal trading unit is called a "lakh", equal to 100 000 oz. but other trading units are also traded.

The Commodities Exchange, Inc. (COMEX) in New York plays a central role among world markets trading in silver futures contracts. The COMEX contract is for 5000 oz. with a limit on daily price changes of 50¢/oz. on forward months. The COMEX is also one of the most active of the silver options markets.

Silver prices peaked at just over US$8.00/oz. in July. The price had risen, partially due to the labour strike in Peru. Overall, silver prices averaged US$6.51/oz. during 1988, down from $7.02 in 1987.

Large silver stocks are the major damping factor on any potential price rally for silver. When prices rise significantly, those holding silver stocks tend to sell causing the price to decline.

OUTLOOK

The silver market remains characterized by high production and stocks and relatively flat consumption. Although industrial demand is showing some signs of increasing, investment demand remains weak. As a result, silver prices are not expected to strengthen significantly in 1989, and will likely remain in the US$5.00-7.00 range.

On the supply side, there is a growing concern about silver production increasing as a result of the development of new gold and base metal mines which contain significant quantities of recoverable silver. For example, Echo Bay Mines Ltd.'s Cove gold mine will produce 5 million oz. of silver in 1990 and ultimately 8 million/y. Consolidated TVX Mining Corporation's new copper mine in Chile will produce more than 8 million oz. by 1991, FMC Corporation's Paradise Peak gold mine in Nevada will produce 4-5 million oz. and Placer Dome Inc.'s Misima gold project in Papua New Guinea will produce 7 million oz. Cominco Ltd.'s Red Dog zinc-lead mine in Alaska will produce 5 million oz./y. These five projects alone will add nearly 10% to current production levels, but many other new mines under development will also recover significant quantities of silver.

TABLE 1A. CANADA, SILVER PRODUCTION AND TRADE, 1985-87

	1985 (kilograms)	1986 (kilograms)	1987 (kilograms)
Production[1]			
By province and territories			
Nova Scotia	-	-	175
New Brunswick	175 419	162 869	182 139
Quebec	61 436	62 232	162 596
Ontario	455 644	347 624	440 819
Manitoba	40 179	37 416	40 992
Saskatchewan	5 581	3 145	1 762
Alberta	-	2	1
British Columbia	379 277	379 966	400 650
Yukon Territories	46 966	73 061	132 822
Northwest Territories	32 570	21 674	12 988
Total	1 197 072	1 087 989	1 374 946
Total Value (C$000)	333 839	275 011	424 064

	1985		1986		1987	
	(kilograms)	($000)	(kilograms)	($000)	(kilograms)	($000)
Exports						
Silver in ores and concentrates						
Japan	242 600	48 887	247 892	45 072	278 881	58 898
Belgium-Luxembourg	9 667	1 893	19 602	2 269	54 628	13 196
Italy	10 458	1 001	10 124	1 052	25 354	5 216
Australia	-	-	5 301	674	26 834	4 773
West Germany	16 348	1 728	6 729[r]	613[r]	27 043	4 585
United States	32 026	5 032	42 104	7 868	20 394	3 298
Finland	933	48	-	-	14 898	2 607
People's Republic of China	3 859	1 004	6 495[r]	1 326[r]	8 040	1 639
United Kingdom	8 969	789	8 603	715	9 421	1 190
Other	13 974	2 572	26 382[r]	4 143[r]	22 742	4 699
Total	338 834	62 954	373 232[r]	63 732[r]	488 235	100 101
Refined metal						
United States	1 324 540	360 324	1 289 239[r]	318 067[r]	547 956	161 663
Singapore	-	-	-	-	3 104	976
France	-	-	-	-	1 700	424
Jamaica	72	22	197	56	655	223
Australia	-	-	-	-	907	5
Other	1 082[r]	362[r]	3 116[r]	717[r]	1 343	350
Total	1 325 694	360 709	1 292 552[r]	318 840[r]	555 665	163 641
Imports						
Silver in ores and concentrates						
Peru	53 048	11 467	74 096	13 329	79 460	16 661
Italy	-	-	-	-	29 324	6 219
Chile	9 569	2 279	5 745	1 185	19 927	5 020
United States	11 572	2 700	14 186	3 411	8 003	2 190
Mexico	-	-	-	-	7 898	1 791
Bolivia	3 687	816	5 282	1 020	6 379	1 713
Other	22 640	4 311	18 887	3 233	3 866	1 097
Total	100 516	21 573	118 196	22 178	154 858	34 691
Refined metal						
United States	540 052	146 443	155 126[r]	35 622[r]	128 470	35 175
Puerto Rico	-	-	678	369	688	382
West Germany	8 627	2 128	3 071	592	1 187	211
United Kingdom	986	54	1 325	73	2 040	53
Other	26 150	8 901	8 874[r]	1 186	8 575	2 760
Total	575 815	157 526	169 074[r]	37 842[r]	140 960	38 580

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Includes recoverable silver in: ores, concentrates and matte shipped for export; crude gold bullion produced; blister and anode copper produced at Canadian smelters; and base and other bullion produced from domestic ores.

[r] Revised; - Nil.

Note: Totals may not add due to rounding.

TABLE 1B. CANADA, SILVER PRODUCTION AND TRADE, 1988P

Item No.		1988P	
		(kilograms)	
Production (shipments)			
Newfoundland		x	
Prince Edward Island		-	
Nova Scotia		x	
New Brunswick		201 500	
Quebec		122 160	
Ontario		386 000	
Manitoba		28 000	
Saskatchewan		x	
Alberta		2	
British Columbia		420 000	
Yukon		340 000	
Northwest Territories		27 400	
Total		1 527 052	
Total Value (C$000)		378 136	
		(Jan.-Sept.)	
		(kilograms)	($000)
Exports			
2603.00	Copper ores and concentrates		
2603.00.81	------Silver content	210 127	47 867
2607.00	Lead ores and concentrates		
2607.00.81	------Silver content	91 113	14 579
2608.00	Zinc ores and concentrates		
2608.00.81	------Silver content	31 989	4 900
26.16	Precious metal ores and concentrates		
2616.10	-Silver ores and concentrates		
	Belgium	1 467	3 963
	West Germany	995	3 500
	United States	3 686	2 798
	Finland	2	33
	Total	6 150	10 294
2616.10.81	------Silver content (included above)	5 665	861
71.06	Silver (including silver plated with gold or platinum), unwrought or in semi-manufactured forms, or in powder form		
7106.10	-Powder	2 721	70
	-Other		
7106.91	--Unwrought	883 144	239 812
7106.92	--Semi-manufactured	7 571	1 958
Imports			
2603.00.00	Copper ores and concentrates		
2603.00.00.81	------Silver content	5 913 554	1 507
2604.00.00	Nickel ores and concentrates		
2604.00.00.81	------Silver content	2	..
2607.00.00	Lead ores and concentrates		
2607.00.00.81	------Silver content	106 894	20 871

TABLE 1B. (cont'd)

Item No.		1988[P] Jan.-Sept. (kilograms)	1988[P] Jan.-Sept. ($000)
Imports (cont'd)			
2608.00.00	Zinc ores and concentrates		
2608.00.00.81	------Silver content	6 893	1 534
26.16	Precious metal ores and concentrates		
2616.10.00	-Silver ores and concentrates		
	Bolivia	24 618	625
	Mexico	341	313
	United States	40 307	291
	Total	65 266	1 229
2616.10.00.81	------Silver content (included above)	1 734	471
71.06	Silver (including silver plated with gold or platinum), unwrought or in semi-manufactured forms, or in powder form		
7106.10	-Powder	3 976	1 322
	-Other		
7106.91	--Unwrought	52 891	15 923
7106.92	--Semi-manufactured	14 645	3 702
7107.00.00.00	Base metals clad with silver, not further worked than semi-manufactured	851	403

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Includes recoverable silver in: ores, concentrates and matte shipped for export; crude gold bullion produced; blister and anode copper produced at Canadian smelters; and base and other bullion produced from domestic ores.

P Preliminary; - Nil; .. Not available or not applicable; x Confidential.

TABLE 2. CANADA, SILVER PRODUCTION, TRADE AND CONSUMPTION, 1975, 1980, 1982-87

	Production[1]	Exports: In Ores and Concentrates	Exports: Refined Silver	Exports: Total	Imports, Refined Silver	Consumption[2] Refined Silver
			(kilograms)			
1975	1 234 642	471 410	713 566	1 184 976	420 078	642 089
1980	1 070 000	396 690	881 761	1 278 451	339 180	265 938
1982	1 313 630	602 603	1 134 347	1 736 950	484 240	180 459
1983	1 197 031	439 406	1 045 867	1 485 273	339 439	283 349
1984	1 326 720	423 963	1 081 391	1 505 354	215 192	299 440
1985	1 197 072	338 834[r]	1 325 694[r]	1 664 528[r]	575 815	217 613[r]
1986	1 087 989	373 232[r]	1 292 552[r]	1 665 784[r]	169 074[r]	312 905[r]
1987	1 374 946	488 235	555 665	1 043 900	140 960	331 245

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Includes recoverable silver in: ores, concentrates and matte shipped for export; crude gold bullion produced; blister and anode copper produced at Canadian smelters; and base and other bullion produced from domestic ores. [2] In some years includes only partial consumption for coinage.

[r] Revised.

TABLE 3. SILVER MINE PRODUCTION IN THE NON-COMMUNIST WORLD, 1983-88

	1983	1984	1985	1986	1987	1988[e]
				(tonnes)		
Latin America						
Mexico	1 978	1 987	2 153	2 308	2 270	2 400
Peru	1 728	1 663	1 770	1 926	2 054	2 070
Chile	468	490	518	500	498	513
Brazil	55	67	67	58	55	60
Bolivia	187	142	111	95	95	100
Other	201	188	228	180	157	242
Total Latin America	4 617	4 537	4 847	5 067	5 129	5 385
Canada	1 197	1 171	1 197	1 088	1 375	1 527
United States	1 350	1 382	1 224	1 064	1 160	1 460
Europe	726	751	810	815	814	791
Africa						
South Africa	203	218	208	223	208	225
Morocco	119	127	127	165	180	200
Namibia	110	106	106	117	120	120
Other	104	98	96	100	99	98
Total Africa	536	549	537	605	607	643
Asia						
Japan	307	324	340	325	290	300
Philippines	59	50	54	53	51	51
South Korea	67	70	70	80	80	82
Other	102	141	141	184	156	150
Total Asia	535	585	605	642	577	583
Oceania						
Australia	1 033	972	1 086	1 009	1 025	1 100
Papua New Guinea	48	45	46	57	51	55
Other	1	1	1	1	1	1
Total Oceania	1 081	1 018	1 133	1 067	1 077	1 156
Total	10 042	9 993	10 353	10 348	10 739	11 545

Sources: Shearson Lehman Brothers Annual Silver Review 1988; Energy, Mines and Resources Canada; The Silver Institute.

[e] Estimate.

TABLE 4. AVERAGE ANNUAL SILVER PRICES, 1970-88

Year	Canada (C$/oz.)	United States (US$/oz.)	United Kingdom (£/oz.)
1970	1.851	1.771	73.778
1971	1.571	1.546	63.086
1972	1.671	1.685	67.403
1973	2.567	2.558	103.783
1974	4.595	4.708	199.819
1975	4.503	4.419	200.118
1976	4.291	4.353	242.423
1977	4.922	4.623	265.512
1978	6.171	5.401	282.203
1979	12.974	11.094	519.607
1980	24.099	20.632	900.778
1981	12.617	10.518	515.303
1982	9.831	7.947	455.331
1983	14.154	11.441	753.644
1984	10.521	8.141	607.056
1985	8.364	6.142	477.560
1986	7.532	5.470	373.030
1987	8.877	7.001	428.243
1988	8.325	6.535	366.783

Sources: Northern Miner, Handy & Harman and London Metal Exchange.

TABLE 5. CANADIAN CONSUMPTION[1] OF UNMANUFACTURED SILVER, 1986 AND 1987

	1986	1987
	(kilograms)	
Silver Salts	150 861	139 635
Coinage	(2)	127 741
Silver Alloys	21 457	16 754
Wire, Rod and Sheet	10 460	11 222
Sterling and Electro-plating	24 491	11 198
Other Uses	105 637	24 697
Total	312 906	331 247

Source: Energy, Mines and Resources Canada.

[1] Available data as reported by consumers.

(2) 1986 coinage is included in Sterling and Electroplating due to confidentiality.

TABLE 6. MONTHLY AVERAGE SILVER PRICES, 1987 and 1988

	London Metal Exchange		Handy & Harman	
	(C$/oz.)	(US$/oz.)	(C$/oz.)	(US$/oz.)
1987				
January	7.52	5.53	7.52	5.53
February	7.31	5.48	7.33	5.49
March	7.46	5.66	7.49	5.68
April	9.83	7.44	9.82	7.43
May	11.40	8.51	11.32	8.44
June	9.96	7.44	9.92	7.41
July	10.13	7.64	10.18	7.68
August	10.43	7.87	10.40	7.85
September	9.99	7.59	9.98	7.59
October	9.95	7.60	9.90	7.56
November	8.80	6.69	8.77	6.66
December	8.89	6.80	8.88	6.79
1988				
January	8.62	6.71	8.65	6.73
February	8.01	6.31	8.02	6.32
March	7.98	6.39	8.01	6.41
April	7.94	6.43	8.00	6.48
May	8.07	6.52	8.10	6.54
June	8.52	6.99	8.56	7.04
July	8.54	7.08	8.63	7.15
August	8.19	6.70	8.22	6.72
September	7.81	6.36	7.84	6.38
October	7.56	6.27	7.57	6.28
November	7.65	6.28	7.66	6.28
December	7.30	6.11	7.31	6.11

Sources: London Metal Exchange; Handy & Harman.

TABLE 7. SILVER CONSUMPTION IN MAJOR NON-SOCIALIST COUNTRIES

	1983	1984	1985	1986	1987
			(tonnes)		
Industrial Uses					
United States	3 617.3	3 570.7	3 688.9	3 698.2	3 586.2
Canada	276.8	279.9	283.0	298.6	323.5
Mexico	68.4	108.9	158.6	152.4	136.9
United Kingdom	559.9	591.0	591.0	637.6	668.7
France	578.5	528.8	559.9	510.1	609.6
West Germany	942.4	936.2	986.0	1 147.7	1 259.7
Italy	279.9	360.8	143.1	451.0	311.0
Japan	2 223.9	2 447.8	2 342.1	2 634.5	2 699.8
India	401.2	500.8	650.1	500.8	500.8
Others	1 648.5	1 664.0	1 707.6	1 810.2	1 866.2
Total	5 265.8	5 234.7	5 396.5	5 508.4	5 452.4
Coinage					
United States	348.4	105.8	136.9	230.2	410.6
Canada	12.4	9.3	9.3	62.2	99.5
Austria	62.2	0.0	0.0	31.1	62.2
Mexico	0.0	62.2	93.3	52.9	15.6
Others	143.1	93.3	155.5	432.3	379.5
Total	566.1	270.6	395.0	808.7	967.3
Grand Total	5 831.9	5 505.3	5 791.5	6 317.1	6 419.8

Source: Handy & Harman, "The Silver Market 1987".

Sodium Sulphate

G. BARRY

Sodium sulphate is mainly produced from natural brines and deposits in alkaline lakes in areas with dry climates and restricted drainage, from subsurface deposits and brines, or as a by-product of chemical processes. Canada's sodium sulphate industry is based on extraction from natural brines and deposits in several alkaline lakes in Saskatchewan and Alberta. Seven plants producing natural sodium sulphate operated in Canada in 1988. By-product sodium sulphate is recovered at one rayon plant.

World production in 1988 was estimated at approximately 4 Mt, split about 45% between natural sources and 55% from various manufacturing processes, mainly as a by-product of viscose rayon production, hydrochloric acid, sodium dichromate and about six other chemical processes.

In the United States, natural and by-product sodium sulphate production is almost evenly split, with three natural producer having a total of 500 000 t/y capacity and about 10 synthetic producers with a total capacity of 485 000 t/y. In 10 European countries, sodium sulphate is produced almost entirely as a by-product of chemical processes, with a total capacity of 1.8 Mt/y. In addition Spain has 0.4 Mt/y of natural sodium sulphate capacity.

PRODUCTION AND DEVELOPMENTS IN CANADA

Demand for Canadian natural sodium sulphate fell principally as a result of a decline in exports to the United States. The Saskatchewan and Alberta producers responded by reducing production levels and trimming employment for the third year in a row. Mine production in 1988 (1987) was 297 000 t (342 400 t) and corresponding mine shipment were 309 800 t (342 076 t). Inventories declined marginally. The average unit value of shipments declined from $77.60 in 1987 to $74.31 in 1988. There was a shift in sales volume to the lower priced salt cake which would accentuate the decline in unit value. Exports to the United States dropped by 5.6% for the first nine months of 1988 compared to the same period last year.

Besides natural sodium sulphate, about 20 000 t/y are produced as a by-product of chemical processes in central Canada. Between 35% and 45% of the total amount of sodium sulphate produced in Canada is the higher-grade and higher-priced "detergent-grade".

Potash Corporation of Saskatchewan (PCS) closed its sodium sulphate plant located at the Cory potash mine site in July 1988. The plant operated for about two and a half years, and never reached its designed output of 30 000 t/y. The plant is currently mothballed.

In July of 1987, PCS completed the construction of a 10 t/d plant for the production of industrial grade potassium sulphate at Big Quill Lakes. The plant uses the ion exchange process to produce a very pure, fine grain industrial product to a specification of 99.7% K_2SO_4. The plant produces a good product but is still operating at only about 6.5 t/d.

In January 1985, Alberta Sulphate Limited, then entirely owned by Agassiz Resources Ltd., acquired the Francana operations from Hudson Bay Mining and Smelting Co., Limited. The two deposits in Saskatchewan (Snakehole and Alsask Lakes) and the deposit in Alberta (Metiskow Lake) are now all operated under the name: Francana Minerals Inc. a division of Agassiz Resources Ltd. In 1988 the three operations produced at less than two-thirds of their combined capacity.

Saskatchewan Minerals, a provincial government owned company was sold to Kam-Kotia Mines Limited at the beginning of 1988. The two mines, Chaplin and Ingebrigt operated without problems but only at just over 50% of capacity.

G. Barry is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 992-7568.

Millar Western Industries Ltd. and Ormiston Mining and Smelting Co. Ltd. operated at below 50% of capacity.

Deposits. The sodium sulphate deposits in Saskatchewan and Alberta have formed in shallow, undrained lakes and ponds where inflow is greater than outflow. Percolating ground waters carry dissolved salts into the basins from the surrounding soils. High rates of summer evaporation concentrate the brine to near saturation, and cooler fall temperatures cause crystallization and precipitation of sodium sulphate as mirabilite ($Na_2SO_4.10H_2O$). The cycle has been repeated year after year and thick deposits of hydrous sodium sulphate, accompanied by other salts and mud, have accumulated.

Identified deposits in Saskatchewan contain, in total, approximately 90 Mt of anhydrous sodium sulphate. Of this amount, a total of about 51 Mt is in 21 individual deposits, each containing more than 500 000 t of sodium sulphate. Exploitation currently takes place on the following lakes (with reserves, in Mt, in brackets): Whiteshore Lake (6.0), Horseshoe Lake (2.7), Chaplin Lake (2.4), Ingebrigt Lake (8.1), Alsask Lake (2.0), East Coteau Lake (3.4), and Snakehole Lake and Verlo Lake (1.2), all in Saskatchewan. Production in Alberta is from Metiskow Lake (0.9).

Recovery and processing. Because most of the sodium sulphate is recovered by evaporation of concentrated brines or by dredging of the permanent beds of crystals, weather is as important for recovery of sodium sulphate as it is for its deposition. A large supply of fresh water is also essential. One method of sodium sulphate recovery is to pump lake brines that have been concentrated by hot summer weather into evaporating ponds or reservoirs. Continued evaporation produces a saturated or near-saturated solution of mirabilite. Differential crystallization occurs in the fall when the solution cools. Hydrous sodium sulphate crystallizes and precipitates, whereas sodium chloride, magnesium sulphate and other constituents remain in solution. Before freezing weather sets in, the impure solution remaining in the reservoir is drained or pumped back into the source lake. After the crystal bed has become frozen, harvesting is carried out using conventional earthmoving equipment. The harvested crystal is stockpiled adjacent to the plant.

Some operators used floating dredges to mine the permanent crystal bed. The slurry of crystal and brine is transported to a screening house at the plant by pipeline. If sufficiently concentrated, the brine from the screens is collected in an evaporation pond.

Since 1984, one company uses solution mining in lake beds that are 3 to 11 m thick. It pumps a concentrated brine to an air-cooled crystallizer at the plant where sodium sulphate is separated from other more soluble salts.

Processing of the natural salt consists of dehydration (Glauber's salt contains 55.9% water of crystallization) and drying. Commercial processes used in Saskatchewan include Holland evaporators, gas-fired rotary kilns, submerged combustion and multiple effect evaporators. Subsequent crushing and screening results in a product with uniform grain size and good flow characteristics. Salt cake, the product used principally in the pulp and paper industry, contains a minimum of 97% Na_2SO_4. Detergent-grade material analyzes up to 99.7% Na_2SO_4. Uniform grain size and free-flow characteristics are important in material handling and use.

Of the seven plants in the Prairies, four are capable of producing detergent-grade sodium sulphate. Three plants have the capacity to produce 80% or more of their output as a high-grade product. The natural sodium sulphate industry employed about 240 persons in 1987, compared to about 300 in 1986.

By-product recovery. In 1988, Courtaulds (Canada) Inc. produced just over 20 000 t of detergent-grade sodium sulphate as a by-product of viscose rayon production at its Cornwall, Ontario plant. Capacity at the Cornwall plant is in the order of 24 000 t/y; it will be raised to about 27 000 t/y in 1989.

The Quebec and Ontario Paper Company Limited at Thorold, Ontario produced approximately 67 000 t of salt cake in 1987 as a by-product of paper manufacturing. The plant was closed on December 18, 1987, but the company continued to sell salt cake from their stocks until June 1988. There are no plans to re-open the plant.

PRICES

Canadian list prices for natural sodium sulphate f.o.b. western plants were approximately $81 and $101/t respectively for salt cake and detergent-grade in 1988. However, in practice, much lower prices were realized throughout the year. Realized prices are expected to rise \$5 to \$7/t in 1989. Prices for detergent-grade by-product sodium sulphate in Ontario were in the order of \$180 to \$185/t in bulk shipment. For bagged product, the quote on Dec. 1, 1988 was \$219/t.

USES

The main end-uses for sodium sulphate are in the pulp and paper, detergent, glass and dyeing industries.

In the chemical pulping of wood, the digestion reagents consist of about two-thirds caustic soda and one-third sodium sulphide obtained by using sodium sulphate as make-up. About 33% of sulphur input is retained in the organic chemicals recycled in the process. Lately, technical improvements in the process significantly reduced the consumption of sodium sulphate per tonne of pulp produced, to 20 kg/t or less. The reduction in purchases is also due to the increasing use of chlorine dioxide as a bleaching agent. This bleaching chemical is manufactured internally and a sodium sulphate slurry is its by-product in many mills. Caustic soda and emulsified sulphur can be substituted for salt cake. Partial substitution reduces sulphur emissions thus facilitating compliance with stricter environmental controls. The U.S. paper and pulp market accounts for 25% of salt cake usage.

Sodium sulphate is used as a builder, or more correctly as a diluent in detergents (supplies the "bulk"). It is claimed to improve detergency through its effect on the colloidal properties of the cleaning system but is essentially inert. The curtailment in the usage of sodium tripolyphosphate (STPP) on grounds of pollution control also contributed to a decline in sodium sulphate. The average sodium sulphate content of powder detergents is now around 30% in North America and Japan but is lower in Europe. Roskill Information Services Ltd. estimates that sodium sulphate used in detergents of all types accounted for 21% of world consumption (1983). In the United States detergents represent 50% of the market for sodium sulphate but rapid growth in liquid detergents has had a negative impact on demand.

Some sodium sulphate is used by the glass industry as a source of Na_2O to speed up melting and prevent scum forming on the surface of the melt. For typical container glass, sodium sulphate used is 0.36% of the weight of the glass produced; while flat glass requires 5 to 10 parts of sodium sulphate per 1000 parts of silica sand. However, particularly in the manufacture of flat glass, and specialty glasses, calcium sulphate and soda ash can partially replace sodium sulphate. Both natural and synthetic salt cake can be used providing that the Fe_2O_3 content is less than 0.15%. Sodium sulphate in glass accounts for 5% of U.S. consumption.

Sodium sulphate is also used in the textile industry in the dyeing process, particularly of wool.

Sodium sulphate is used in the manufacture of a number of chemicals such as potassium sulphate, sodium sulphide, sodium silicate, sodium hyposulphite and sodium aluminum sulphate. Sodium sulphide is quantitatively the most important and is used for de-hairing hides in the tanning process.

Other end-uses include the manufacture of viscose sponges, feed supplements, boiler feed water treatments, veterinary medicines, sulphonated oils, printing inks, the ceramic industry and the photographic industry.

Since 1981, a potential new use for sodium sulphate was in coal-fired power plants. Sodium sulphate is added to coal as a conditioner since it improves the efficiency of high-temperature electrostatic precipitators by preventing clogging by fly-ash. Only about 5 kg of sodium sulphate is used for a tonne of coal. However, acceptance of this usage is disappointing and only two plants in the United States were known to have used this process.

Experiments were conducted in using sodium sulphate as a heat storage medium in solar energy conservation (heating) projects. To date, usage is limited, however, and it appears that another chemical, calcium chloride hexahydrate is a better material for heat-storage cells.

In the United Kingdom, research is conducted on a scrubbing liquor using sodium sulphate to remove sulphur dioxide and nitrogen from stack gas.

OUTLOOK

On balance the North American natural sodium sulphate industry is expected to experience a flat growth in consumption over the next few years; some analysts expect a slight negative growth.

Canadian shipments in 1988 were at the same low level as in 1987. It appears however that the substitution of sodium sulphate by caustic soda and emulsified sulphur in the North American pulp and paper industry ran its course and from 1988 onward, there is even a possibility of a very small increase in this vital market. The unit consumption downtrend from about 40 kg/t of pulp in 1980 to about 20 kg/t in 1987 has also run its course, with possible further declines in the western states compensated by increases in the east.

In the detergent industry a world wide growth of 1 and 2% is still possible, but in the United States, the rapid substitution of powder detergents by liquid detergents, which contain no sodium sulphate, may still result in a slight overall decline in sodium sulphate consumption. Liquid detergents now account for 40% of the U.S. market. On the positive side, The Procter & Gamble Company increased its demand by a reformulation of their soap products.

The United States consumes a quarter of the world production of sodium sulphate, averaging over 1.0 Mt for the past few years but it fell to 0.8 to 0.9 Mt in 1987 and 1988 and may reach 1.0 Mt again in 1989. Canadian exports to the United States are expected to increase by some 20% in 1989.

For the world, the medium-term forecast growth rate in demand is between 0.5% and 1.0%/y.

TABLE 1A. CANADA, NATURAL SODIUM SULPHATE PRODUCTION AND TRADE, 1986 AND 1987

	1986		1987	
	(tonnes)	($)	(tonnes)	($)
Production				
Shipments				
Saskatchewan	x	29 037 668	x	23 514 414
Alberta	x	3 973 836	x	3 030 993
Total	370 726	33 011 504	342 076	26 545 407
Imports				
Total salt cake and Glauber's salt				
United Kingdom	16 658	1 476 911	15 187	705 977
United States	845	171 865	1 984	536 397
Other countries	48	15 882	22	8 669
Total	17 551	1 664 658	17 193	1 251 043
Exports				
Crude sodium sulphate				
United States	220 502	23 646 418	150 840	15 687 055
New Zealand	11 984	805 948	17 113	1 281 630
Other countries	904	179 535	142	35 453
Total	233 390	24 631 901	168 095	17 004 138

Sources: Energy, Mines and Resources Canada; Statistics Canada.
x Confidential.

TABLE 1B. CANADA, NATURAL SODIUM SULPHATE PRODUCTION AND TRADE 1988P

		1988P	
		(tonnes)	($000)
Production			
Shipments			
Saskatchewan		x	19 891 850
Alberta		x	3 128 000
Total		309 800	23 019 850
Imports		(Jan.-Sept.)	
2833.11	Disodium Sulphate		
	United Kingdom	5 718	318 000
	United States	689	84 000
	West Germany	12	1 000
	Total	6 419	403 000
Exports			
2833.11	Disodium Sulphate		
	United States	99 281	10 175 000
	Venezuela	5 060	607 000
	Other countries	2	120 000
	Total	104 343	10 902 000

Sources: Energy Mines and Resources Canada; Statistics Canada.
P Preliminary; x Confidential.

TABLE 2. CANADA, NATURAL SODIUM SULPHATE PLANTS, 1988

	Plant Location	Source Lake	Annual Capacity (tonnes)
Alberta			
Agassiz Resources Ltd.[1]	Metiskow	Metiskow	55 000
Saskatchewan			
Agassiz Resources Ltd.[1]	Cabri	Snakehole and Verlo	60 000
Agassiz Resources Ltd.[1]	Hardene	Alsask	45 000
Millar Western Industries Ltd.	Palo	Whiteshore	109 000
Ormiston Mining and Smelting Co. Ltd.	Ormiston	Horseshoe	90 700
Saskatchewan Minerals[2]	Chaplin	Chaplin	90 000
Saskatchewan Minerals[2]	Fox Valley	Ingebrigt	163 000
Total			612 700

Source: Company reports.
[1] Francana Minerals Inc. [2] A division of Kam-Kotia Mines Limited.

TABLE 3. CANADA, SODIUM SULPHATE PRODUCTION, TRADE AND CONSUMPTION 1970, 1975, AND 1980-88

	Production[1]	Imports[2]	Exports	Consumption[3]
	(tonnes)			
1970	445 017	26 449	108 761	291 439
1975	472 196	22 638	178 182	256 385
1980	496 000	20 211	245 831	232 045
1981	535 000	24 960	284 281	216 298
1982	547 000	17 293	367 924	191 988
1983	453 939	22 479	265 752	190 625
1984	389 086	20 584	238 749	235 504
1985	366 217	33 426	210 851	241 143
1986	370 726	17 551	233 390	228 360
1987	342 076	17 193	168 095	188 626
1988P	309 800	..	..	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Producers' shipments of crude sodium sulphate. [2] Includes Glauber's salt and crude salt cake. [3] Available data as reported by consumers.
P Preliminary; .. Not available.

TABLE 4. CANADA, AVAILABLE DATA ON SODIUM SULPHATE CONSUMPTION[1], 1985-87

	1985	1986	1987P
	(tonnes)		
Pulp and paper	184 087	164 061	142 370
Cleansers	47 906	54 808	38 707
Primary glass and containers	7 655	7 471	6 714
Other products[2]	1 495	2 020	835
Total	241 143	228 360	188 626

[1] Available data, as reported by consumers.
[2] Nonferrous smelting and refining, feed industry and other minor uses.
P Preliminary.

Stone

O. VAGT

SUMMARY

Production of all types of stone in 1988, including crushed material and certain chemical grades, remained about the same in terms of quantity but increased in value to more than $600 million, according to preliminary figures.

Considerable additional data, particularly on standard and lightweight aggregates, is included in the chapter on "Mineral Aggregates."

Strong demand continued for dimension stone mainly for exterior and interior finish for office buildings in the United States and Canada. Fabrication of thin custom veneer and panels, along with the automated manufacture of granite tiles using the latest European technology, has contributed greatly to the value of output. More recently, demand for premium-quality crude granite block, particularly from Quebec, has increased substantially. Available quantitative data is lacking on rough stone and fabricated products on a national as well as a provincial basis. However in Quebec, the value of production of shaped, construction-quality granite from both domestic and imported block is estimated to have increased about ten fold during the period from 1980-88 inclusive.

CANADIAN DEVELOPMENTS

A relatively small proportion of all stone production in terms of volume relates to dimension stone, however the most rapid expansion has occurred in this sector. Production of granite in particular has grown considerably and the wide variety of available attractive raw material is becoming more recognized. Most activity is situated in Quebec (80-90%) and Ontario, both recognized as sources of superior quality stone (Figure 1). Limestone/marble, sandstone and slate are also important in certain regions, as shown. The value of production of rough granite, mainly from Quebec, indicates an eight-fold increase from 15 000 t valued at $850 000 in 1977 to 57 000 t valued at $7.3 million in 1986 (Figure 2).

Rough granite for building construction increased in relative importance from about 24% of total sales by use to 70% of sales during the period 1977-86. Correspondingly, stone used for monumental/ornamental purposes declined in relative importance but grew in absolute terms. The use of limestone and marble in construction has also increased, particularly during the past two years, however, up-to-date data is not available.

Since 1982 the relatively strong United States dollar has maintained the competitiveness of many imported products including dimension stone finished at modern European plants. Similarly, with established expertise and good access to domestic and imported raw material, Canadian producers installed new capacity using mainly Italian technology. In Quebec, Granicor inc., associated with Olympia & York Developments Ltd. and Campolonghi SpA opened several quarries in the past few years to supply high-quality granite in a range of colors. Also, members of the Quebec Granite Producers Association as well as independent operators expanded and reported substantial growth in production as well as exports. In Ontario, Nelson Granite Limited was considering construction of a plant to produce architectural products to complement the existing manufacture of monuments and curbing. Canroc Manufacturing Limited Partnership, of Delta, British Columbia, continued development work on several quarries to provide additional raw material for the company's modern stone processing plant serving markets in western North America and the Pacific Rim.

Several provinces are assessing their building stone resources with a view to serving foreign and domestic markets for finished stone. These initiatives are often assisted through federal-provincial Mineral Development Agreements as part of Economic and Regional Development Agreements

---

O. Vagt is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 992-2667.

(ERDA's). Promotional literature and display samples also make up part of these projects.

Most dimension stone, including granite, limestone, marble, sandstone and slate is used in construction-oriented projects. Chemical uses relate mainly to limestone and are limited to the cement, lime, glass and metal smelting industries.

Most provincial authorities record stone-related data and have published information. The federal government, through the Geological Survey of Canada, has assembled many geological papers relating to stone. Also, works by W.A. Parks[1] and by M.F. Goudge[2] have become classics and remain applicable in many areas.

Atlantic provinces

Limestone. The many occurrences of limestone in the Atlantic provinces have been systematically catalogued during the past[3,4,5]. Deposits of commercial importance are being worked in three of the four provinces.

In Newfoundland, limestone is available from small, impure exposures in the eastern portion of the island, from small, high-calcium deposits in the central region, and from large, high-purity, high-calcium occurrences in the west. Other than periodic operation to secure aggregate for highway work, the main exploitation has been by North Star Cement Limited at Corner Brook[6]. However in western Labrador, the Iron Ore Company of Canada (IOC) brought into production a dolomitic marble for use in self-fluxing "dolomitic-type" iron ore pellets[7]. In 1988, The Newfoundland Resources & Mining Company Limited, controlled by Explaura Holdings PLC of the United Kingdom, continued development of its tidewater property on the Port-au-Port Peninsula to quarry and ship limestone aggregates. Plans call for shipping 1-2 Mt/y with increases to 3-5 Mt within 5 years.

In Nova Scotia, limestone occurs in the central and eastern parts of the province and in New Brunswick is quarried at three locations - Brookville, Elm Tree and Havelock - for use as crushed stone aggregate, for agricultural application, for lime manufacture, and for use as a flux. Studies continued to assess opportunities associated with the dimension and crushed stone industries.

Granite. Occurrences of granite in the Atlantic region have been described by Carr[8]. In Nova Scotia, a grey granite is produced from operations near Nictaux and from one quarry at Shelburne for use mainly in the monument industry. A black granite from Shelburne and a diorite from Erinville have been used for monuments and for dimension stone. Some activity relating to granite, as well as other types of stone, was summarized in a recent Nova Scotia publication[9]. Construction Aggregates Ltd., of Nova Scotia, now owned by Lone Star Industries, Inc. of Greenwich, Conn., continued shipping high-quality granite construction aggregate from the company's Strait of Canso quarry. Sea-going barges and ships are loaded at the plant site and delivery is to aggregate-poor regions as distant as Houston, Texas.

Granite is quarried intermittently from a number of deposits in New Brunswick to obtain stone of required colour and texture for specific applications. A red, fine- to medium-grained granite is quarried near St. Stephen, and fine-grained, pink, grey and blue-grey granites are available in the Hampstead (Spoon Island) district. In the Bathurst area, a brown-to-grey, coarse-grained granite is quarried upon demand, as is a salmon-coloured, medium-grained granite near Antinouri Lake, and a black, ferromagnesian rock in the Bocabec River area. Red granite is available in the St. George district. Manufacturers of monument stone continue to import dark, crude granite from South Africa.

In Newfoundland, there is a recognized potential for the development of labradorite deposits in the Nain River area of Labrador.[7]

Sandstone and Slate. Island Tile & Slate Limited, after start-up in 1986, continued producing slate from a quarry at Nut Cove, near Bourgoyne's Cove, Trinity Bay, Newfoundland. Red, green and purple-coloured products are available for uses in roofing and flooring. In Nova-Scotia, medium-grained buff sandstone is quarried at Wallace, for use as heavy riprap and for dimension stone.

In New Brunswick, a red, fine- to medium-grained sandstone has been quarried in Sackville for use in construction. Deposits are exploited intermittently throughout Kent and Westmorland counties for local projects and for highway work.

Quebec

Limestone. Limestone occurs in the St. Lawrence and Ottawa River valleys and in the Eastern Townships. Limestone blocks and other shapes are produced for the construction trade in the Montreal region and at various locations throughout the province. Marble has been produced in the Eastern Townships and the Lac St-Jean areas.

Granite. Quebec, the major Canadian producer, accounts for up to 90% of total granite shipments used as dimension stone for construction-related and monumental/ornamental uses. Since 1979, total shipments of rough and partially finished stone have doubled, and according to estimates the value of construction-quality granite from domestic and imported block increased from about $11 million to more than $100 million in 1988. As a result of improved marketing and advanced processing technology, 24 companies now quarry granite mainly in the Rivière-à-Pierre, the Lac St-Jean and the Appalachians regions.[10]

Sandstone. Of six operations producing from sandstone resources in Quebec only one is listed as marketing flagstone and construction blocks, in Hemmingford, Huntingdon County.

Ontario

Limestone. Although limestones in Ontario range from Precambrian through Devonian, the major production comes from Ordovician, Silurian and Devonian deposits[11,12]. A major provincially-funded study was in progress to assess the limestone industries of Ontario, and to describe their overall potential based on available resources.

Marble. This is widely distributed over southeastern Ontario and, according to the Ontario Ministry of Natural Resources reports, underlies as much as 250 square kilometres (km^2)[13].

Steep Rock Calcite, a division of Steep Rock Resources Inc., produces medium- to high-grade calcium carbonate at Tatlock and Perth for the filler and extender markets.

Granite. Granites occur in northern, northwestern and southeastern Ontario[14,15,16,17]. Few deposits have been exploited in the past for building stone because the major-consuming centres are in southern and southwestern Ontario where good-quality limestones and sandstones are readily available. The most active centres of production are the Vermilion Bay area near Kenora, the River Valley area near North Bay, and the Lyndhurst-Gananoque area in southeastern Ontario. Activity throughout the province is highlighted in an annual directory.[18]

Sandstone. Sandstone quarried near Toronto, Ottawa and Kingston has been used widely in Ontario as building stone[19]. Medina sandstones vary from grey, through buff and brown to red, and some are mottled. They are fine- to medium-grained. The Potsdam stone is medium grained; the colour ranges from grey-white through salmon-red to purple, and it can also be mottled. Current uses are as rough building stone, mill blocks from which sawn pieces are obtained, ashlar, flagstone and as a source of silica for ferrosilicon and glass.

Western provinces

Limestone. From east to west through the southern half of Manitoba rocks of Precambrian, Ordovician, Silurian, Devonian and Cretaceous ages are represented. Limestones of commercial importance occur in the three middle periods and range from magnesian limestone through dolomite to high-calcium limestones[2,20]. A recent publication includes current developments relating to limestone as well as other types of stone[21].

Tyndall Stone, a mottled dolomitic limestone often referred to as "tapestry" stone, is the best known Manitoba limestone. It is widely used as an attractive building stone, and is quarried at Garson, about 50 km northeast of Winnipeg. Limestone from Moosehorn, 160 km northwest of Winnipeg and from Mafeking, 40 km east of the Saskatchewan border and 160 km south of The Pas, is transported to Manitoba and Saskatchewan centres for use in the metallurgical, chemical, agricultural and construction industries.

The eastern ranges of the Rocky Mountains contain Cambrian to Triassic limestones. Major deposits characterized by a wide variety of types occur in Devonian and Carboniferous rocks[22]. In southwestern Alberta, high-calcium limestone is mined at Exshaw, Kananaskis and Crowsnest, chiefly for the production of cement and lime, for metallurgical and chemical uses and for use as a crushed stone. Similar uses are made of limestone quarried at Cadomin, near Jasper[6].

In British Columbia, large volumes of limestone are mined each year for cement and lime manufacture, for use by the pulp and paper industry and for various construction applications[6]. Quarries on Texada Island, British Columbia have for many years provided limestone to markets in Vancouver and in Washington state by virtue of their quality and position relative to tidewater shipping facilities. Deposits on Aristazabal Island have been developed for the export market. Other operations at Terrace, Clinton, Westwold, Popkum, Dahl Lake, Doeye River and Cobble Hill produced stone for construction and for filler use[23]. Periodically, interest is revived in the possible use of travertine from a British Columbia source.

Granite. In Manitoba, at Lac du Bonnet northeast of Winnipeg, a durable, pink granite is quarried for building and monument use. Grey granite located east of Winnipeg near the Ontario border is a potential source of building stone. Approximately ten Manitoba granite occurrences were assessed recently under a federal-provincial Mineral Development Agreement to determine their physical and aesthetic qualities.

In British Columbia, a light-grey, to blue-grey even-grained granodiorite of medium texture is available from Nelson Island and other areas. Andesite has been quarried at Haddington Island, off the northeast coast of Vancouver Island, for use as a building stone. Canroc produced a range of products from its own coral-coloured granite and from other local and imported stone. A recent publication including photographs by the Province of British Columbia highlights current and past quarrying and uses relating to granite, marble, flagstone, jade and rhodonite.[24]

Sandstone. Sandstone for building and ornamental uses, quarried near Banff, Alberta is hard, fine-grained, medium-grey and is referred to as "Rundal Stone".

USES

Limestones are widely distributed in Canada and are generally available in sufficient quantity and with such chemical or physical specifications that long transportation hauls are unnecessary. Limestone products are low-priced commodities and only rarely, when a market exists for a high-quality, specialized product such as white portland cement or a high-purity extender, are they beneficiated or moved long distances. Provided the specifications are met, the nearest source is usually considered, regardless of provincial or national boundaries.

Some major uses in the chemical field are: neutralization of acid waste liquors; extraction of aluminum oxide from bauxite; manufacture of soda ash, calcium carbide, calcium nitrate and carbon dioxide; in pharmaceuticals; as a disinfectant; in the manufacture of dyes, rayons, paper, sugar and glass; and in the treatment of water. Dolomitic limestone is used in the production of magnesium chloride and other magnesium compounds.

Agricultural limestone is used to control soil acidity and to add calcium and magnesium to the soil. Limestone and lime are used as soil stabilizers, particularly on highway construction projects.

Dolomite is the source of magnesium metal produced at Haley, Ontario; the company also uses a high-calcium lime from southeastern Ontario in the production of calcium metal. Dead-burned dolomitic limestone for use as a refractory is produced at Dundas, Ontario, by Steetley Quarry Products Inc. A magnesite deposit at Eon Mountain in British Columbia has been quarried by Baymag Mines Co. Limited since 1982 to produce caustic magnesia, refractory grade MgO, and more recently, fused magnesia. Calcining is done in a refurbished kiln on the property of LaFarge Canada Inc. at Exshaw, Alberta.

As a dimension stone, granite is processed for interior and exterior floor- and wall-covering, modular block panelling and for monument stone. Uniformity of colour and texture, and durability are the main features sought. Quarrying takes into account geological and structural features as well as topography and accessibility.

OUTLOOK

The dimension stone industry, given new technology relating to quarrying, fabrication and installation - along with continuing favourable economic conditions - is expected to continue to grow. Although the most rapid expansion has been associated with Quebec granite, modernization by several producers across Canada has increased the availability of high-quality finished products at competitive prices. Markets for building stone continue to face competition from substitutes such as aluminum, concrete, glass and ceramics. However use of modern gang saws for cutting thin panels for cladding to be fitted to steel or concrete construction units is expected to continue improving cost effectiveness. For aesthetic reasons, demand for natural materials and products at least partially based on these, are expected to expand as new markets are developed. Efforts continue on behalf of the industry to illustrate to architects and developers the availability of a wide range of Canadian building stones and their adaptability in modern design.

REFERENCES

1. Parks, W.A., Building and Ornamental Stones of Canada, Canada Department of Mines, Mines Branch, Ottawa, Nos. 100, 203, 279, 388 and 452, Volume 1 (1912) to Volume V (1971) OUT OF PRINT.

2. Goudge, M.F., Limestones of Canada, Canada Department of Mines, Mines Branch, Ottawa, Nos. 733, 742, 755, 781, 811, Part 1, (1934) to Part V (1946) OUT OF PRINT.

3. DeGrace, John R., Limestone Resources of Newfoundland and Labrador, Department of Mines and Energy, Mineral Development Division, St. John's, Newfoundland, Report 74-2, 1974.

4. Shea, F.S., Murray, D.A., Limestones and Dolomites of Nova Scotia, Department of Mines, Halifax, N.S., Part I, Bulletin No. 2, 1967 and Part II Bulletin No. 2, 1975.

5. Hamilton, J.B., Limestone in New Brunswick, Department of Natural Resources, Mineral Resources Branch, Fredericton, N.B., Mineral Resources Report No. 2, 1965.

6. Vagt, G.O., Cement, Canadian Minerals Yearbook, 1987 Department of Energy, Mines and Resources Canada, Mineral Policy Sector, Ottawa.

7. Dean, P.L., Meyer, J.R. and Howse, A.F. Industrial Minerals Operations in Newfoundland and Labrador, Newfoundland/Labrador Department of Mines and Energy, 1987.

8. Carr, G.F., The Granite Industry of Canada, Canada Department of Mines and Technical Surveys, Mines Branch, Ottawa, Ontario, No. 846, 1955.

9. Dickie, G.B., Building Stone in Nova Scotia, Nova Scotia Department of Mines and Energy, Halifax, Information Circular 12, 1988.

10. Nantel, S., Carrières de Granite Architectural et Ornamental Exploitées au Québec, 1987.

11. Ontario Department of Mines, Toronto, Industrial Mineral Circular No. 5, 1960.

12. Hewitt, D.F., Vos. M.A., The Limestone Industries of Ontario, Ontario Ministry Natural Resources Division of Mines, Toronto, Industry Mineral Report No. 39, 1972.

13. Hewitt, D.F., Building Stones of Ontario, Part III, Marble, Ontario Department of Mines, Toronto, Industrial Mineral Report No. 16, 1964.

14. Hewitt, D.F., Building Stones of Ontario, Part V, Granite and Gneiss, Ontario Department of Mines, Toronto, Industrial Mineral Report No. 19, 1964.

15. Vos M.A., Smith, B.A., Stevenato, R.J., Industrial Minerals of the Sudbury Area, Ontario Geological Survey, Open File Report No. 5329, 1981, 156p.

16. Verschuren, C.P., van Haaften, S. and Kingston, P.W., Building Stones of Eastern Ontario, Southern Ontario - 1985; Ontario Geological Survey, Open File Report 5556, 116p.

17. Beard, R.C., and Kennedy, M.C., Building and Ornamental Stone in Northwestern Ontario, Canadian Institute of Mining and Metallurgy, unpublished, 1987.

18. Industrial Minerals Section, Building Stone Quarries in Ontario - A Directory, Ministry of Northern Development and Mines, Mines and Minerals Division, May 1988.

19. Hewitt, D.F., Building Stone of Ontario, Part IV, Sandstone, Ontario Department of Mines, Toronto, Industrial Mineral Report No. 17, 1964.

20. Bannatyne, B.B., High-Calcium Limestone deposits of Manitoba, Manitoba Department of Mines, Resources and Environmental Management, Mineral Resources Division, Exploration and Geological Survey Branch, Winnipeg, Publication 75-1, 1975.

21. Gunter, R. and Segard, S. Industrial Minerals of Manitoba, Manitoba Energy and Mines, Minerals Division, Open File Report OF 85-7.

22. Holter, M.E., Limestones Resources of Alberta, Transactions, Canadian Institute of Mining and Metallurgy, Bull. V.76, 1971.

23. McCammon, J.W., Sadar, E., Robinson, W.C., Robinson, J.W., Geology Exploration and Mining in British Columbia, 1974, British Columbia Department of Mines and Petroleum Resources.

24. White, G.V. and Hora, Z.D., British Columbia Dimension Stone, Ministry of Energy, Mines and Petroleum Resources, Mineral Resources Division, Geological Survey Branch, Victoria, Information Circular 1988-6.

Item No.	Description	Canada MFN	Canada GPT	Canada USA	United States Canada
2514.00	Slate whether or not roughly trimmed or merely cut, by sawing or otherwise into blocks or slabs of a rectangular (including square) shape				
2514.00.10	--- Crude or roughly trimmed	Free	Free	Free	Free
2514.00.20	--- Merely cut by sawing or otherwise into blocks or slabs	5.5%	3.5%	Free	Free
2514.00.90	--- Other, including powder and waste	10.2%	6.5%	Free	Free
	- Marble and travertine				
2515.11.00	-- Crude or roughly trimmed	Free	Free	Free	Free
2515.12.00	-- Merely cut, by sawing or otherwise into blocks or slabs	4%	Free	Free	Free
2515.20	- Ecaussine and other calcareous monumental or building stone; alabaster				
2515.20.10	--- Crude or roughly trimmed	Free	Free	Free	Free
2515.20.20	--- Merely cut, by sawing or otherwise into blocks or slabs	5.5%	3.5%	Free	Free
	- Granite				
2516.11	-- Crude or roughly trimmed	Free	Free	Free	Free
2516.12	-- Merely cut, by sawing or otherwise into blocks or slabs	5.5%	Free	Free	Free
	- Sandstone				
2516.21.00	-- Crude or roughly trimmed	Free	Free	Free	Free
2516.22.00	-- Merely cut, by sawing or otherwise, into blocks or slabs	5.5%	3.5%	Free	Free
2516.90	- Other monumental or building stone				
2516.90.10	--- Crude or roughly trimmed	Free	Free	Free	Free
2516.90.20	--- Merely cut, by sawing or otherwise, into blocks or slabs	5.5%	3.5%	Free	Free

TARIFFS (cont'd)

Item No.	Description	Canada			United States
		MFN	GPT	USA	Canada
2517.10.10	- Pebbles, gravel, broken or crushed stone, of a kind commonly used for concrete aggregates, etc.	Free	Free	Free	Free
2517.20	- Macadam of slag dross or similar industrial waste	Free	Free	Free	Free
	- Granules, chippings and powder, of stones of heading No. 25.15 or 25.16, whether or not heat treated				
2517.41	-- Of marble	Free	Free	Free	Free
2517.49	-- Other				
2517.49.10	--- Limestone roofing granules	Free	Free	Free	Free
2517.49.90	--- Other	10.2%	6.5%	8.1%	Free
6801.00	Setts, curbstones and flagstones of natural stone (except slate)	5.5%	Free	4.4%	3.3%
6802.10	- Tiles, cubes and similar articles, whether or not rectangular (including square), not more than 7 cm; artificially coloured granules, chippings and powder				
6802.10.10	--- Roofing granules, artificially coloured	Free	Free	Free	5.5%
6802.10.90	--- Other	12.5%	8%	10%	5.5%
	- Other monumental or building stone and articles thereof, simply cut or sawn, with a flat or even surface				
6802.21	-- Marble, travertine and alabaster	5.7%	3.5%	4.5%	4.8%
6802.22	-- Other calcareous stone	8%	5%	6.4%	4.8%
6802.23	-- Granite	5.5%	Free	Free	Free
6802.29	-- Other stone	8%	5%	6.4%	6%

	- Other				
6802.91	-- Marble travertine and alabaster	9%	Free	7.2%	2.2%-4.8%
6802.92	-- Other calcareous stone	9.9%	6.5%	7.9%	4.8%
6802.93	-- Granite	10.2%	6.5%	Free	Free
6802.99	-- Other stone	10.2%	6.5%	8.1%	5.2%
6803.00	Worked slate and articles of slate or of agglomerated slate				
6803.00.10	--- Roofing slate	Free	Free	Free	5.2%
6803.00.90	--- Other	10.2%	6.5%	8.1%	2.9%
6804.10.00	- Millstones and grindstones for milling, grinding or pulping	10.2%	Free	Free	Free
6804.23.00	-- Of natural stone	10.2%	Free	Free	Free

Sources: Customs Tariffs, effective January 1989, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States (First Edition Supplement 2) effective January 1, 1989.

TABLE 1. CANADA, TOTAL PRODUCTION OF STONE, 1986-88

	1986		1987		1988P	
	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)
By province[1]						
Newfoundland	476	2 712	931	8 535	990	9 158
Nova Scotia	4 023	21 944	4 437	23 133	4 450	22 695
New Brunswick	2 344	13 064	2 878	15 934	2 960	16 280
Quebec	36 066	172 194	42 731	213 112	43 007	217 762
Ontario	45 477	226 130	52 412	273 032	51 000	280 500
Manitoba	4 100	26 831	3 760	15 959	3 500	14 000
Saskatchewan	-	-	2	4	2	4
Alberta	229	1 315	249	1 532	300	2 100
British Columbia	4 403	23 049	5 213	29 544	4 913	34 388
Northwest Territories and Yukon	484	1 416	678	2 165	1 300	4 425
Canada	97 602	488 655	113 291	582 950	112 422	601 312
By use[2]						
Dimensional stone						
Rough	154	11 542	..	..	..	..
Monumental and ornamental stone (n.f.)	74	8 405	..	..	..	..
Other (flagstone, curbstone, paving blocks, etc.)	28	2 203	..	..	..	..
Chemical and metallurgical						
Cement plants, Canada	11 535	23 315	..	..	..	..
Cement plants, foreign	468	1 316	..	..	..	..
Lining, open-hearth furnaces	-	-	..	..	..	..
Flux in iron and steel furnaces	1 065	4 401	..	..	..	..
Flux in nonferrous smelters	62	1 445	..	..	..	..
Glass factories	190	3 423	..	..	..	..
Lime plants, Canada	3 556	18 288	..	..	..	..
Lime kilns, foreign	396	1 740	..	..	..	..
Pulp and paper mills	240	1 903	..	..	..	..
Sugar refineries	32	159	..	..	..	..
Other chemical uses	617	3 967	..	..	..	..
Pulverized stone						
Whiting (substitute)	32	1 938	..	..	..	..
Asphalt filler	108	657	..	..	..	..
Dusting, coal mines	6	188	..	..	..	..
Agricultural purposes and fertilizer plants	1 122	13 532	..	..	..	..
Other uses	243	9 887	..	..	..	..
Crushed stone for						
Manufacture of artificial stone	17	413	..	..	..	..
Roofing granules	358	6 644	..	..	..	..
Poultry grit	58	2 300	..	..	..	..
Stucco dash	3	212	..	..	..	..
Terrazzo chips	4	134	..	..	..	..
Rock wool	-	-	..	..	..	..
Rubble and riprap	1 651	9 654	..	..	..	..
Concrete aggregate	11 966	61 400	..	..	..	..
Asphalt aggregate	8 169	37 520	..	..	..	..
Road metal	41 044	174 808	..	..	..	..
Railroad ballast	3 247	19 025	..	..	..	..
Other uses	26 249	109 840	..	..	..	..
Total	112 693	530 258	..	..	..	..

---

[1] Data excludes stone used in the Canadian cement and lime industries. [2] Data includes stone used in the Canadian cement and lime industries.
P Preliminary; .. Not available; - Nil; n.f. Not finished or dressed.
Totals may not add due to rounding.

TABLE 2. CANADA, PRODUCTION OF LIMESTONE, 1985-87

	1985[1]		1986[1]		1987[2]	
	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)
By province						
Newfoundland	215	1 479	262	1 512	379	4 463
Nova Scotia	1 290	6 399	619	3 543	210	2 181
New Brunswick	603	5 123	1 107	6 392	627	6 012
Quebec	26 459	110 025	30 721	126 559	33 562	148 515
Ontario	41 453	162 992	51 470	218 416	49 349	242 125
Manitoba	3 434	10 555	3 801	20 549	3 049	11 445
Saskatchewan	-	-	-	-	2	4
Alberta	1 349	6 946	1 354	6 031	212	1 429
British Columbia	2 998	14 098	2 950	14 519	2 123	11 112
Northwest Territories and Yukon	73	245	342	1 057	245	1 037
Canada	77 874	317 862	92 625	398 578	89 759	428 324
By use						
Dimensional stone						
Rough	179	1 767	49	1 636	..	..
Monumental and ornamental stone (n.f.)	1	75	-	-	..	..
Other (flagstone, curbstone, paving blocks, etc.)	14	741	15	1 097	..	..
Chemical and metallurgical						
Cement plants, foreign	546	1 527	468	1 316	..	..
Lining, open-hearth furnaces	-	-	-	-	..	..
Flux, iron and steel furnaces	1 155	4 893	1 065	4 401	..	..
Flux, nonferrous smelters	75	1 759	62	1 443	..	..
Glass factories	228	4 357	190	3 423	..	..
Lime kilns, foreign	288	1 159	396	1 740	..	..
Pulp and paper mills	187	1 335	230	1 745	..	..
Sugar refineries	23	261	32	159	..	..
Other chemical uses	569	4 977	617	3 967	..	..
Cement plants, Canadian	8 264	23 031	11 306	22 675	..	..
Lime plants, Canadian	5 137	15 504	3 556	18 288	..	..
Pulverized stone						
Whiting substitute	27	1 487	32	1 938	..	..
Asphalt filler	48	495	52	495	..	..
Dusting, coal mines	7	196	6	188	..	..
Agricultural purposes and fertilizer plants	1 123	13 222	1 046	12 349	..	..
Other uses	46	446	25	424	..	..
Crushed stone for						
Artificial stone	-	-	-	-	..	..
Roofing granules	86	926	99	1 170	..	..
Poultry grit	31	820	55	2 073	..	..
Stucco dash	11	553	-	-	..	..
Rock wool	-	-	-	-	..	..
Rubble and riprap	818	3 391	521	2 060	..	..
Concrete aggregate	7 042	30 613	10 661	53 790	..	..
Asphalt aggregate	5 715	24 103	6 446	28 357	..	..
Road metal	20 946	80 524	36 413	153 380	..	..
Railroad ballast	984	3 405	915	3 451	..	..
Other uses	24 324	96 295	18 368	77 013	..	..
Total	77 874	317 862	92 625	398 578		

---

[1] Data includes stone used in the Canadian cement and lime industries. [2] Data excludes stone used in the Canadian cement and lime industries.
- Nil; .. Not available; n.f. Not finished or dressed.
Totals may not add due to rounding.

TABLE 3. CANADA, PRODUCTION OF MARBLE, 1985-87

	1985		1986		1987	
	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)
By province						
Nova Scotia	2	130	3	151	3	155
Quebec	381	5 116	369	5 133	487	7 153
Ontario	188	8 720	189	8 928	222	10 580
Canada	571	13 966	560	14 213	712	17 887
By use						
Dimensional stone						
Rough	18	665	20	882	..	..
Monumental and ornamental stone (n.f.)	5	535	3	359	..	..
Chemical process stone						
Flux in nonferrous smelters	...	1	...	1	..	..
Pulp and paper mills	5	73	10	158	..	..
Other chemical uses	-	-	-	-	..	..
Pulverized stone						
Whiting	-	-	-	-	..	..
Agricultural purposes and fertilizer plants	95	1 513	76	1 182	..	..
Other uses	200	9 463	218	9 463	..	..
Crushed stone for						
Artificial stone	10	203	17	413	..	..
Roofing granules	1	31	2	52	..	..
Poultry grit	...	1	...	5	..	..
Stucco dash	3	105	2	119	..	..
Terrazzo chips	5	124	4	134	..	..
Concrete aggregate	32	220	44	369	..	..
Road metal	73	230	57	243	..	..
Other uses	124	802	107	832	..	..
Total	571	13 966	560	14 213		

- Nil; ... Amount too small to be expressed; .. Not available; n.f. Not finished or dressed.
Totals may not add due to rounding.

TABLE 4. CANADA, PRODUCTION OF GRANITE, 1985-87

	1985		1986		1987	
	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)
By province						
Newfoundland	105	616	94	666	480	3 539
Nova Scotia	2 582	13 971	2 705	14 742	2 826	14 609
New Brunswick	1 671	6 924	1 724	7 750	2 023	9 321
Quebec	4 371	30 092	4 565	33 500	6 047	42 733
Ontario	2 523	14 834	1 363	15 618	1 744	16 988
Manitoba	1 242	6 712	846	7 855	620	4 495
Alberta	-	-	-	-	-	-
British Columbia	4 695	22 145	2 874	13 431	3 082	18 287
Northwest Territories and Yukon	30	130	4	20	136	597
Canada	17 219	95 424	14 176	93 583	16 957	110 569
By use						
Dimensional stone						
Rough	57	6 904	57	7 309	..	..
Monumental and ornamental (n.f.)	38	5 399	53	7 396	..	..
Other (flagstone, curbstone, paving blocks, etc.)	9	500	11	1 002	..	..
Chemical and metallurgical lining, open-hearth furnaces	-	-	-	-	..	..
Pulverized stone						
Asphalt filler	193	2 657	56	162	..	..
Crushed stone for						
Roofing granules	248	458	256	5 421	..	..
Poultry grit	-	1	2	169	..	..
Stucco dash	4	327	-	-	..	..
Rubble and riprap	1 772	6 013	1 051	7 363	..	..
Concrete aggregate	1 506	6 312	981	5 618	..	..
Asphalt aggregate	1 150	5 803	1 508	8 242	..	..
Road metal	3 531	15 219	3 449	16 670	..	..
Railroad ballast	4 485	30 085	2 333	15 574	..	..
Other uses	4 225	15 747	4 419	18 657	..	..
Total	17 219	95 424	14 176	93 583		

- Nil; .. Not available; n.f. Not finished or dressed.
Totals may not add due to rounding.

TABLE 5. CANADA, PRODUCTION OF SANDSTONE, 1985-87

	1985		1986		1987	
	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)
By province						
Newfoundland	341	1 556	191	1 009	64	462
Nova Scotia	1 081	4 901	1 083	4 980	1 337	6 130
New Brunswick	260	375	117	58	141	81
Quebec	1 309	8 054	1 386	8 652	1 621	11 086
Ontario	19	353	58	598	189	1 595
Alberta	1	64	1	57	1	42
British Columbia	...	7	25	235	7	145
Canada	3 011	15 310	2 861	15 588	3 360	19 542
By use						
Dimensional stone						
Rough	26	1 247	28	1 612	..	..
Monumental and ornamental (n.f.)	15	517	18	651	..	..
Other (flagstone, curbstone, paving blocks, etc.)	2	97	2	103	..	..
Crushed stone for						
Rubble and riprap	189	567	79	231	..	..
Concrete aggregate	213	1 300	281	1 622	..	..
Asphalt aggregate	123	614	215	921	..	..
Road metal	501	2 009	571	2 553	..	..
Railroad ballast	230	919	-	-	..	..
Other uses	1 712	8 040	1 668	7 894	..	..
Total	3 011	15 310	2 861	15 588		

- Nil; ... Amount too small to be expressed; .. Not available; n.f. Not finished or dressed.

Totals may not add due to rounding.

TABLE 6. CANADA, PRODUCTION OF SHALE, 1985-87

	1985[2]		1986[2]		1987[3]	
	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)
By province						
Newfoundland[1]	10	34	17	145	8	71
Nova Scotia	1	...	27	25	61	58
New Brunswick	-	-	9	62	86	520
Quebec	429	1 278	990	3 193	1 014	3 625
Ontario[1]	857	1 192	1 018	3 862	909	1 744
Manitoba	1	10	...	2	91	19
Alberta	203	486	271	668	37	60
Northwest Territories	60	59	138	339	297	531
Canada	1 561	3 059	2 471	8 296	2 503	6 628
By use						
Dimensional stone[1]	-	-	...	102	..	..
Chemical and metallurgical						
Cement plants, Canadian	203	485	229	641	..	..
Crushed stone for						
Rubble and riprap	9	39	...	...	..	..
Road metal	220	764	553	1 962	..	..
Other uses	1 129	1 772	1 689	5 592	..	..
Total	1 561	3 060	2 471	8 296		

[1] Includes slate. [2] Data includes stone used in the Canadian cement and lime industries.
[3] Data excludes stone used in the Canadian cement and lime industries.
- Nil; ... Amount too small to be expressed; .. Not available.
Totals may not add due to rounding.

TABLE 7. CANADA, PRODUCTION OF STONE BY TYPES[1], 1975, 1980, 1986 AND 1987

	1975		1980		1986		1987	
	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)
Granite	11 470	34 913	39 983	140 914	14 176	93 583	16 957	110 569
Limestone	72 284	152 521	58 191	185 085	77 763	357 616	89 759	428 324
Marble	356	1 843	316	1 807	560	14 213	712	17 887
Sandstone	3 753	10 881	3 064	11 540	2 861	15 588	3 360	19 542
Shale[2]	1 551	2 566	1 812	1 810	2 242	7 655	2 503	6 628
Total	89 414	202 724	103 366	341 156	97 602	488 655	113 291	582 950

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Data excludes stone used in the Canadian cement and lime industries. [2] Includes slate.

TABLE 8. CANADA, STONE EXPORTS AND IMPORTS, 1986 AND 1987

	1986		1987	
	(tonnes)	($000)	(tonnes)	($000)
Exports				
Building stone, rough	18 450r	2 674	37 450r	5 990
Stone crude, n.e.s.	329 832	3 016	739 128	5 383
Natural stone, basic products	..	29 186	..	30 966
Total	..	34 876	..	42 339
Imports				
Building stone, rough	10 622	1 853	18 174	2 383
Stone crude, n.e.s.	6 257	463	8 152	645
Granite, rough	33 995	6 646	46 369	7 866
Marble, rough	6 137	2 725	6 075	2 771
Shaped or dressed granite	..	11 224	..	16 051
Shaped or dressed marble	..	8 792	..	15 056
Natural stone basic products	..	15 357	..	22 042
Total	..	47 060	..	66 814

Source: Statistics Canada.
r Revised by EMR; n.e.s. Not elsewhere specified; .. Not available.

TABLE 8A. CANADA, STONE EXPORTS AND IMPORTS, 1988P

		1988P Jan.-Sept.	
		(tonnes)	($000)
Exports			
2514.00	Slate, whe[illegible] or not roughly trimmed or merely cut, etc.	105	11
2515.11	Marble and travertine, crude or roughly trimmed	555	328
2515.12	Marble and travertine, merely cut, by sawing or otherwise into blocks, etc.	460	1 102
2516.11	Granite crude or roughly trimmed	7 294	1 179
2516.12	Granite, merely cut, by sawing or otherwise into blocks, etc.	52 898	9 809
2516.21	Sandstone crude or roughly trimmed	8 300	37
2516.22	Sandstone merely cut, by sawing or otherwise into blocks, etc.	1 935	64
2516.90	Monumental or building stone n.e.s.	341	255
2517.10	Pebbles, gravel broken or crushed stone used for aggregates, etc.	1 452 620	9 588
2517.41	Marble granules, chipping and powder of 25.15 or 25.16 heat-treated or not	1 908	502
2517.49	Granules, chippings and powder, n.e.s. of 25.15 or 25.16 heat-treated or not	101 274	591
6801.00	Setts, curbstones and flagstones of natural stone (except slate)	..	9
6802.10	Tiles etc. rectangular or square not more than 7 cm., etc.; artificially coloured granules, chippings and powder	700	653
6802.21	Monumental or building stone, cut or sawn, flat or even, marble, travertine and alabaster	..	560
6802.22	Monumental or building stone, cut or sawn, flat or even, other calcareous stone	..	18
6802.23	Monumental or building stone, cut or sawn, flat or even, granite	..	8 374
6802.29	Monumental or building stone, cut or sawn, flat or even, n.e.s.	..	174
6802.91	Worked monumental or building stone n.e.s., marble, travertine or alabaster	..	261
6802.92	Worked monumental or building stone n.e.s., calcareous stone n.e.s.	..	1
6802.93	Worked monumental or building stone n.e.s., granite	..	9 409
6802.99	Worked monumental or building stone, n.e.s.	..	411
6803.00	Worked slate and articles of slate or agglomerated slate	..	34
6804.10	Millstones and grindstones for milling, grinding or pulping	..	4 153
6804.23	Millstones, grindstones, etc. of natural stone	..	138
Imports			
2514.00	Slate, whether or not roughly trimmed or merely cut, etc.	2 782	492
2515.11	Marble and travertine, crude or roughly trimmed	5 697	1 978
2515.12	Marble and travertine, merely cut, by sawing or otherwise into blocks, etc.	4 040	2 408
2515.20	Ecaussine and other calcareous monumental or building stone; alabaster	48	16
2516.11	Granite crude or roughly trimmed	33 137	6 943
2516.12	Granite, merely cut, by sawing or otherwise into blocks, etc.	3 899	1 679

TABLE 8A. (cont'd)

		1988P Jan.-Sept.	
		(tonnes)	($000)
Imports (cont'd)			
2516.21	Sandstone crude or roughly trimmed	813	95
2516.22	Sandstone merely cut, by sawing or otherwise into blocks, etc.	12 451	1 693
2516.90	Monumental or building stone n.e.s.	9 452	1 026
2517.10	Pebbles, gravel broken or crushed stone used for aggregates, etc.	463 671	2 843
2517.20	Macadam of slag dross or similar industrial waste, etc.	152 375	429
2517.41	Marble granules, chipping and powder of 25.15 or 25.16 heat-treated or not	28 463	2 608
2517.49	Granules, chippings and powder, n.e.s. of 25.15 or 25.16 heat-treated or not	106 038	1 622
6801.00	Setts, curbstones and flagstones of natural stone (except slate)	..	1 026
6802.10	Tiles etc. rectangular or not more than 7 cm., etc.; artificially coloured granules, chippings and powder	27 868	3 175
6802.21	Monumental or building stone, cut or sawn, flat or even, marble, travertine and alabaster	..	1 801
6802.22	Monumental or building stone, cut or sawn, flat or even, other calcareous stone	..	217
6802.23	Monumental or building stone, cut or sawn, flat or even, granite	..	1 870
6802.29	Monumental or building stone, cut or sawn, flat or even, n.e.s.	..	564
6802.91	Worked monumental or building stone n.e.s., marble, travertine or alabaster	..	29 917
6802.92	Worked monumental or building stone n.e.s., calcareous stone n.e.s.	..	94
6802.93	Worked monumental or building stone n.e.s., granite	..	11 789
6802.99	Worked monumental or building stone, n.e.s.	..	507
6803.00	Worked slate and articles of slate or agglomerated slate	25 631	1 626
6804.10	Millstones and grindstones for milling, grinding or pulping	..	1 715
6804.23	Millstones, grindstones, etc. of natural stone	..	1 677

Source: Statistics Canada.
P Preliminary; .. Not available; n.e.s. Not elsewhere specified.

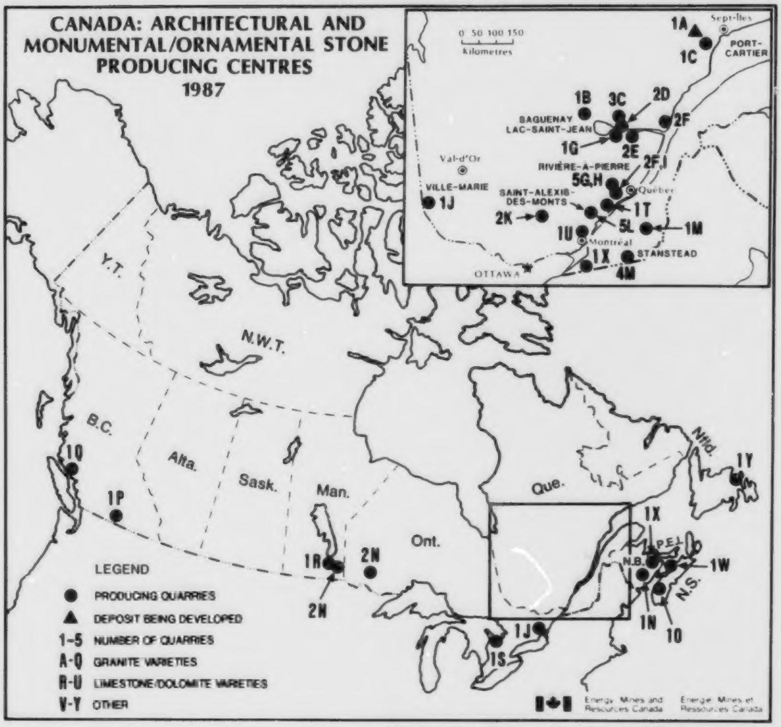
TABLE 9. CANADA, VALUE OF CONSTRUCTION[1] BY PROVINCE, 1986-88

	1986			1987			1988		
	Building Construction	Engineering Construction	Total	Building Construction	Engineering Construction	Total	Building Construction	Engineering Construction	Total
					($000)				
Newfoundland	802 442	809 153	1 611 595	878 732	696 895	1 575 627	898 710	664 234	1 562 944
Nova Scotia	1 493 407	872 077	2 365 484	1 694 516	715 721	2 410 237	1 752 532	785 781	2 538 313
New Brunswick	1 042 640	428 756	1 471 396	1 178 179	465 024	1 643 203	1 229 301	470 882	1 700 183
Prince Edward Island	223 287	70 364	293 651	222 907	72 148	295 055	241 763	86 388	328 151
Quebec	11 690 251	3 888 916	15 579 167	13 971 089	4 158 213	18 129 302	13 799 399	4 888 767	18 688 166
Ontario	19 480 274	5 824 510	25 304 784	24 148 448	6 061 990	30 210 438	24 509 690	6 807 027	31 316 717
Manitoba	1 870 090	928 101	2 798 191	1 992 684	942 052	2 934 736	2 033 533	1 154 802	3 188 335
Saskatchewan	1 563 702	1 396 406	2 960 108	1 808 053	1 502 338	3 310 391	1 792 538	1 732 571	3 525 109
Alberta	4 109 233	6 239 982	10 349 215	4 775 800	5 663 670	10 439 470	4 892 445	7 048 038	11 940 483
British Columbia, Yukon and Northwest Territories	5 151 540	3 815 498	8 967 038	6 557 677	3 349 923	9 907 600	7 126 702	3 363 932	10 490 634
Canada	47 426 866	24 273 763	71 700 629	57 228 085	23 627 974	80 856 059	58 276 613	27 002 422	85 279 035

Source: Statistics Canada.

[1] Actual expenditures 1986, preliminary actual 1987, intentions 1988.

Figure 1


CANADA: ARCHITECTURAL AND MONUMENTAL/ORNAMENTAL STONE PRODUCING CENTRES
1987
0 50 100 150
Kilometres
1A
Sept-Îles
1C
PORT-CARTIER
1B
3C
2D
SAGUENAY
LAC-SAINT-JEAN
2F
1G
2E
Val-d'Or
RIVIÈRE-À-PIERRE
2F,I
5G,H
VILLE-MARIE
1J
SAINT-ALEXIS-DES-MONTS
Québec
2K
1T
5L
1M
1U
Montréal
1X
STANSTEAD
OTTAWA
4M
Y.T.
N.W.T.
B.C.
1O
Alta.
Sask.
Man.
Que.
Nfld.
1Y
1P
Ont.
1X
P.E.I.
1R
2N
N.B.
1W
2N
N.S.
1N
1O
1J
1S
LEGEND
PRODUCING QUARRIES
DEPOSIT BEING DEVELOPED
1-5 NUMBER OF QUARRIES
A-Q GRANITE VARIETIES
R-U LIMESTONE/DOLOMITE VARIETIES
V-Y OTHER
Energy, Mines and Resources Canada
Énergie, Mines et Ressources Canada

Source: Mainly Provincial Departments of Mines and Energy

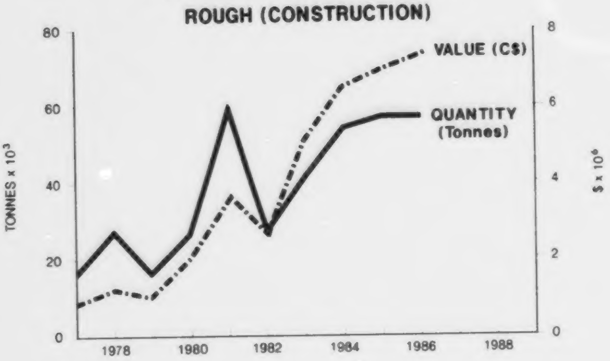
A	FINE-GRAINED PINKISH-GREY BANDED GNEISS
B	MEDIUM-GRAINED MAHOGANY GRANITE
C	COARSE-GRAINED BLACK ANORTHOSITE
D	MEDIUM-GRAINED BLACK GABBROIC ANORTHOSITE
E	MEDIUM-GRAINED PINKISH-GREY QUARTZ MONZONITE
F	FINE-GRAINED PINK GRANITIC GNEISS
G	COARSE-GRAINED GREEN CHARNOCKITE
H	COARSE-GRAINED PINK-GREY OR BROWN-GREY GRANITE
I	MEDIUM GRAINED GREY DIORITIC GNEISS
J	MEDIUM-GRAINED RED GRANITE
K	FINE-GRAINED PINK APLITE
L	COARSE-GRAINED BROWN OR RED QUARTZ MONZONITE
M	MEDIUM-GRAINED GREY GRANITE
N	MEDIUM-GRAINED PINK GRANITE
O	FINE-GRAINED BLUE-GREY GRANITE
P	COARSE CORAL PINK GRANITE
Q	MEDIUM-GRAINED BLUE-GREY GRANITE
R	LIGHT-COLOURED MOTTLED DOLOMITIC LIMESTONE (TYNDALL)
S	FINE-MEDIUM CRYSTALLINE BLUE-GREY TO BUFF MARBLE DOLOSTONE (ARRISCRAFT)
T	MEDIUM-GRAINED LIGHT BROWNISH-GREY LIMESTONE (DESCHAMBAULT)
U	MEDIUM-GRAINED BLUE-GREY LIMESTONE (CHAZY)
V	MEDIUM-GRAINED OLIVE SANDSTONE
W	FINE-MEDIUM-GRAINED OLIVE-BROWN AND BLUE-GREY SANDSTONE
X	FINE MEDIUM GRAINED WHITE TO BUFF SANDSTONE (POTSDAM)
Y	VERY FINE-GRAINED VARICOLOURED SLATE

Figure 2

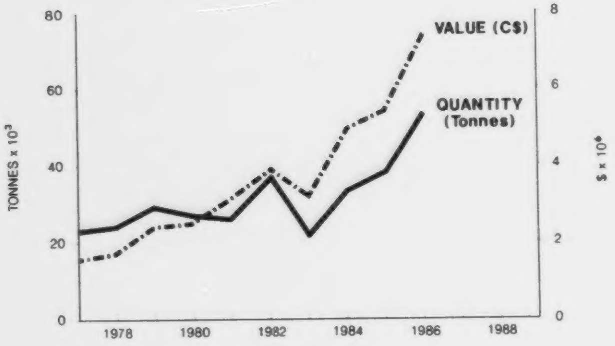
CANADA - PRODUCTION OF DIMENSIONAL GRANITE

(Sold and Used by Producers)

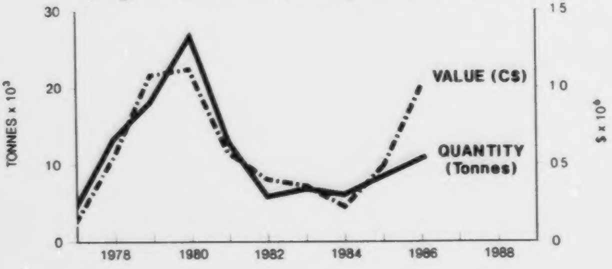
ROUGH (CONSTRUCTION)



MONUMENTAL/ORNAMENTAL



OTHER
(Flagstone, Curbstone, Paving Blocks and Other)



Sulphur

M. PRUD'HOMME

SUMMARY

In 1988, world production of sulphur-in-all-forms has been estimated at 60.37 Mt, a 1.8% increase over 1987; world production of elemental sulphur rose by 1.37 Mt to 37.68 Mt while consumption grew sharply by 7.8% to 40.81 Mt. Trade accounted for 43% of world production of elemental sulphur.

Sulphur production grew in Canada, Saudi Arabia and the U.S.S.R., remained stable in Mexico, West Germany and the United States while it decreased in France and Poland. Consumption was strong in Morocco, Tunisia, Brazil, the United States and India due to the strong performance of the phosphate fertilizer sector.

During 1988, the market for sulphur was essentially in balance but there were pressures for an increase in prices by the end of the year due to the sustained performance of phosphate fertilizers and reduced expectations for the availability of supplies from the U.S.S.R. Increases in demand were met in most part by higher operating rates and heavy withdrawals from vatted stockpiles.

Freight rates were an important factor in sulphur contracts, affecting trade patterns. During the first half of 1988, Canada shipped sulphur mostly to North Africa, and Saudi Arabia shipped sulphur solely to India. During the second half, changes in relative freight charges brought Middle Eastern sulphur in competition with Canadian material in the highly coveted Mediterranean markets.

In North America, strong demand from the phosphate industry in the United States resulted in a number of price increases and higher exports from Canada with better netback than that from offshore sales.

In 1988, producers' stockpiles were heavily drawn from to complement production in meeting demand from the international phosphate industry; world sulphur inventories by year-end were estimated at 10.3 Mt, a 3.6 Mt reduction of which two thirds were from Canada, and the balance mostly from the United States. While France and Mexico did some remelting, the U.S.S.R. started to pour small tonnages from Astrakhan into base-pads. No remelts were reported from the huge above ground stockpiles in Saudi Arabia, but drawdowns are expected in the first half of 1989.

DEVELOPMENTS IN CANADA

Elemental Sulphur

Canadian elemental sulphur production in 1988 increased 2% to 5.97 Mt from natural gas processing plants (90%), oil sands plants (7.5%) and oil refineries. Shipments were estimated at 8.1 Mt, a 10% increase over 1987. Sulphur deliveries in Canada accounted for 10% of total shipments while exports to the United States accounted for 13%. Offshore shipments rose to about 6.3 Mt with major increase in sales to Morocco, Tunisia, the United States, France and South Africa. Remelting increased drastically as withdrawals reached close to 2.2 Mt in 1988, compared to 1.7 Mt in 1987; stockpiles at year-end were estimated at 4.9 Mt. In 1988, Canadian sulphur production accounted for 15% of world elemental sulphur production while Canadian shipments accounted for 43% of world brimstone trade.

The Caroline Area Gas Development Group (CAGDG) was formed during 1988; it is a fourteen company consortium led by Shell Canada Limited, Husky Oil Ltd. and Gulf Canada Resources Limited. The CAGDG announced plans to construct a $600 million sour gas project at Caroline, 120 km northwest of Calgary, Alberta. The Caroline field, discovered in 1986, has reserves estimated at 56.6 billion m^3 of raw gas with a hydrogen sulphide content of 30-35%. Total proven sulphur reserves have been estimated at 20 to 30 Mt. The CAGDG is seeking regulatory approval to begin construction of a three-phase project by the summer of 1989. The project will involve

---

M. Prud'homme is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 992-3258.

two-phase expansions at two existing gas processing plants: Gulf's Strachan plant by mid-1990 and Husky's Ram River plant later in 1990. The third phase calls for the construction of a new 2 600 t/d sulphur plant near James River to be completed by mid-1991. The sulphur recovery facilities will capture 98.9% of sulphur emissions. The processing of Caroline reserves at three facilities will result in operational flexibility and while using available capacity at existing plants. Sulphur will be shipped in solid form to terminals in British Columbia.

In the summer of 1988, Shell Canada Limited announced the discovery of a new commercial gas field at Boulder, in the British Columbia foothills, 130 km west of Dawson Creek. The dry sour natural gas contains about 5% H_2S and 5% CO_2.

Shell Canada Limited, Mobil Oil Canada, Ltd., PanCanadian Petroleum Limited and Norcen Energy Resources Limited announced plans for the construction of a $60 million pilot plant to process super sour natural gas near Sundre, Alberta. Construction is scheduled to start early in 1989 for completion by 1990. The pilot plant will process 170 000 m^3 of super sour gas to produce 204 t/d of liquid sulphur. The five-year program will determine the long-term producibility of the reserves of gas with 90% hydrogen sulphide content. If the test project is successful, a commercial operation could be constructed nearby for the production of 3 500 t/d of sulphur for 25 years.

Husky Oil Operations Ltd. announced plans for a $1.27 billion heavy oil upgrader at Lloydminster in Saskatchewan. The upgrader would have a production capacity of 46 000 bbl./d of high grade synthetic crude. Construction started late in 1988 for completion in 1992. A sulphur recovery unit is to produce up to 70 000 t/y of elemental sulphur from residual gas generated from the upgrading process.

In September, an agreement was proposed between the governments of Canada, Alberta and a group of operators for a $4.1 billion oil sands project in Alberta. The group OSLO (Other Six Leases Operators) is a six-company joint venture led by Esso Resources Canada Ltd. The project would produce up to 270 000 t/y of sulphur as a by-product from bitumen. Basic engineering design is expected to start in 1989, for production by 1996.

During 1988, two companies joined Cansulex Limited. Western Decalta Petroleum (1977) Limited is the main operator at Diamond Valley, Alberta, and is a partner in the Obed sour natural gas project in northwestern Alberta. Brymore Energy Ltd. is a firm dealing in the marketing of sulphur, natural gas and oil within Canada and the United States.

Consumers' Co-operative Refineries Limited commissioned a new $680 million heavy oil upgrader near Regina, Saskatchewan. Operated by NewGrade Energy Inc., the 50 000 bbl./d upgrader will supply Consumer's refinery with oil to be refined into gasoline and oil products. Sulphur capacity is expected to increase from 9 000 t/y to close to 85 000 t/y by the end of 1989.

Petro-Canada Inc. announced a $66 million expansion at the Brazeau River natural sour gas processing plant located about 70 km west of Drayton Valley, Alberta. Started in 1988, the construction will permit the gas processing capacity to triple by late 1989. Sulphur production is expected to increase fourfold to 160 000 t/y. Petro-Canada Inc. is the plant's operator with a 31.5% working interest in the operation.

Syncrude Canada Ltd. inaugurated a $670 million addition to its oil sands operation near Fort McMurray. The Capacity Addition Project (CAP) will increase synthetic crude capacity by 10% to 58 million bbl./d. The project includes a new sulphur recovery unit with a 700 t/d capacity of which only close to 150 t/y will be utilized due to throughput constraints. Sulphur dioxide emissions to the atmosphere have been cut by 90% to 265 t/d.

During the year, several changes in oil and gas company ownership occurred. Late in September, the takeover of Dome Petroleum Limited by Amoco Canada Petroleum Company Ltd. resulted from a $5.5 billion transaction that was initiated in the spring of 1987. Husky Oil Ltd. acquired the assets of Canterra Energy Ltd. for $350 million from Nova Corporation of Alberta. Finally, Texaco Canada Inc. which bought several of Canterra's properties during 1988 was offered for sale by its American parent company.

Sulphuric Acid

In 1988, a strong market for sulphuric acid prevailed in North America due to demand for fertilizers and sustained growth in the pulp and paper sector. Other consuming sectors such as water treatment and titanium dioxide maintained a high level of acid consumption.

Cominco Ltd. started a research study on the treatment of sulphur-sulphidic residues from hydrometallurgical processes. Cominco Ltd. and the Government of Canada are cost sharing the $272 000 study which will be carried out at Cominco's Trail plant in British Columbia. The project will investigate ways to eliminate gas and dust emissions from the hydrometallurgical process and to recover metals and sulphur.

Sherritt Gordon Limited took an option to purchase the fertilizer assets of Western Co-operative Fertilizers Limited in Calgary, Alberta, before the end of 1993. The plant was mothballed in the fall of 1987, and had a capacity to produce ammonium phosphate, phosphoric acid and sulphuric acid (430 000 t/y).

Westcoast Energy Inc., formerly known as Westcoast Transmission Company Limited, signed an agreement with C-I-L Inc. to expand C-I-L's chemical plant at Prince George, British Columbia. The project involves the construction of a new 30 000 t/y liquid sulphur dioxide facility while increasing sulphuric acid capacity by 29% to 45 000 t/y. The $8 million expansion is scheduled for completion by early 1989.

Imperial Chemical Industries plc (ICI) of the United Kingdom decided to restructure its subsidiary C-I-L Inc. of North York, Ontario; the plan calls for the sale of four operations including the sulphur products division and Chemetics International Company. The sulphur products unit produces and markets sulphuric acid and sulphur dioxide; it has brimstone burning plants in Fort Saskatchewan (Alberta), Prince George (British Columbia), Beloeil (Quebec) and Sayreville (New Jersey, United States).

Noranda Minerals Inc. continued the construction of a $125 million sulphuric acid plant at its Horne copper smelter in Rouyn-Noranda, Quebec. The construction contract, awarded to Chemetics International Company, is scheduled for completion by mid-1989. The 350 000 t/y acid plant was designed to cut sulphur dioxide emissions by 50% to 276 000 t/y by 1994. Recently, the company announced that emissions will be further reduced by up to 70% by 1995.

INCO Limited announced plans to comply with the 1994 emissions limits for sulphur dioxide. A $494 million project is to be constructed at the Sudbury smelter to reduce emissions by 60% to 265 000 t/y in 1994. Falconbridge Limited also plans to spend $38 million to meet emission targets. Ontario Hydro is to install scrubbers on two coal fired generating power stations in Nanticoke and Lambton; the $440 million project will cut emissions by 50% to 215 000 t/y.

WORLD DEVELOPMENTS

Elemental Sulphur

U.S.S.R.

The U.S.S.R. remained the world's second largest producer of brimstone as new sour gas related developments in Astrakhan resulted in increasing brimstone production. Over the next decade, the U.S.S.R. is expected to account for most of the world's additional sulphur output; since 1987, large Soviet scale projects have dominated any other expansion. In the spring of 1987, Astrakhan I came on stream with a capacity of 2.15 Mt/y of sulphur; Astrakhan II is planned to be commissioned by early 1989 with an additional 2.15 Mt/y capacity. Further plans call for a third 2.15 Mt/y stage which would increase Astrakhan's sulphur capacity to 6.45 Mt/y. Meanwhile, multi-stage oil and gas related developments have been planned at Tengiz over the next ten years with six incremental 500 000 t/y phases which would bring an additional 3 Mt/y of sulphur capacity on stream in 1998. During 1988, a joint venture petro-chemical complex has been announced at Kulsary, which would yield up to 2 Mt/y of sulphur by 1994. Although there have been many operational and technical problems with the commissioning of Astrakhan I, sulphur production is expected to increase to 93% of design capacity within two years. In 1988, brimstone production, accounting for 57% of production of sulphur-in-all-forms, was estimated at 6.8 Mt of which half was gas recovered.

Additional sulphur production was directed to domestic demand to reduce imports from western world countries. On a nine-month basis in 1988, Soviet imports dropped 42% to 540 000 t, all sourced in Poland; these countries have signed a ten-year contract in 1985, for deliveries of up to 860 000 t/y of Polish sulphur to the U.S.S.R. Despite the emergence of new supplies in the U.S.S.R., trade with Poland is expected to continue because of logistic and geographic advantages; furthermore, swap may become attractive. For the next decade, the U.S.S.R. is expected to be the principal prospect for growth in world sulphur supply. As additional Soviet sulphur becomes available, it is forecast that most of it will go towards fulfilling growing domestic consumption with the excess ready for export by 1991. Meanwhile, the U.S.S.R. announced plans for the construction of shipping infrastructures near Yuzhney and sulphur forming and handling facilities at Astrakhan and Tengiz. Soviet exports are not expected to reach north-eastern Europe nor eastern Europe because of logistics and priorities in sulphur sales; the most probable markets for new Soviet supplies are in the Mediterranean area, possibly through barter agreements. India is a potential market for Soviet sulphur or for Polish material through some swap arrangements with the U.S.S.R. It has been forecast that the main impact of Soviet sulphur in world markets would likely be felt by 1990 onward as surplus approaching 1-1.5 Mt would be available from production and/or inventories.

United States

The United States was the world's largest sulphur producer as well as major Frasch producing country. Production of elemental sulphur in 1988 remained stable at 8.57 Mt of which Frasch sulphur accounted for 34%. Other forms of sulphur (i.e. acid) reached 1 Mt and accounted for 10% of overall sulphur-in-all-forms output. In 1988, sulphur was produced at 173 operations in 31 states. Stock withdrawals amounted to about 1 Mt, a 148% increase over 1987. Apparent consumption was close to 11 Mt in fertilizers (74%), chemicals (10%) and petroleum refining (8%). Imports rose 6% to 1.5 Mt and were mainly from Mexico (27%) and Canada (73%). Sulphur exports continued to decline for the second year to reach 0.95 Mt, a 16% drop over last year.

Freeport Sulphur Co. of New Orleans, a division of Freeport McMoRan Resource Partners, Ltd. reactivated its 650 000 t/y Caminada Frasch mine, offshore of Louisiana. Texasgulf Inc. has recommissioned the 365 000 t/y Commanche Creek Frasch operation in West Texas for production to start in 1989. Strong demand for sulphuric acid resulted in the reactivation of several previously mothballed facilities: CF Industries, Inc. at Barlow, Florida, reopened a 170 000 t/y acid plant; W.R. Grace & Company reactivated a joint venture with USX Corporation; Consolidated Minerals resumed production at the former Amex plant at Piney Point.

Poland

Poland was the second largest exporter of elemental sulphur after Canada. Production in 1988 was estimated at 4.8 Mt, a 2% decline from 1987. Frasch sulphur was mined at Jeziorko, Grzybow and Machow. A new mine at Oziek has been planned to offset the depletion of reserves at Machow and Grzybow; the two-phase project calls for the construction of a 400 000 t/y facility to be completed in 1992 followed by a second expansion to a total capacity of 1.2 Mt/y. Late in 1988, construction at Oziek was reported to suffer further delays due to environmental constraints. In 1988, domestic consumption declined slightly to 1.0 Mt while exports remained stable at 3.9 Mt. Poland exported 80% of its output mainly to eastern Europe (51%), western Europe (24%), North Africa (13%) and South America (9%).

Mexico

In 1988, Mexico produced 2.3 Mt of sulphur of which 80% was Frasch. Domestic consumption rose 9% to 1.0 Mt as a result of higher operating rates at the Lazaro Cardenas fertilizer plant on the Pacific coast. The commissioning of the new 545 000 t/y Otapan mine in 1988 is expected to offset the anticipated depletion of the Jaltipan dome within the next decade. Mexican production of sulphur is forecast to increase by 10% over the next five years. Mexico exported solid and liquid sulphur from the Gulf coast mainly to the United States (60%), and Morocco (30%). Exports rose 7% to 1.2 Mt while inventory dropped slightly to close at 300 000 t during 1988.

Saudi Arabia

In Saudi Arabia, sulphur production has been estimated at 1.3 Mt in 1988, a 15% increase over 1987. Exports grew substantially to 1.2 Mt for markets in India, Morocco, Tunisia and Italy. Sulphur was produced at three gas refineries and inventories were kept near the Berri gas plant. Stockpiles were estimated at 1.5 Mt late in 1988, unchanged from 1987 as all production was sold. New remelting facilities are expected to be operating in 1989. Saudi Arabian sales were mostly delivered to the Indian market during the first half of 1988, but became a factor in the Mediterranean markets as the Government Established Price (GEP) remained unchanged during the second half of 1988. It is expected that Saudi Arabia will continue to maintain a competitive advantage in the lucrative North African market.

France

France is the eighth world major producer of brimstone, recovered from the Lacq natural gas field and from some oil refineries. Gas-related sulphur production continued to decline from 1.8 Mt in 1982 to about 1.0 Mt in 1988, due to reduced recovery from the Lacq operations. Domestic sales remained stable at 650 000 t while exports dropped 7% to 500 000 t; these were mainly delivered to western Europe and North Africa. Inventory levels were virtually unchanged at close to 2.0 Mt. During 1988, exploration activities continued in the Aquitaine basin.

PRICES

Contract prices for offshore exports of elemental sulphur from Vancouver remained quite stable during the first half of 1988 ranging between US$90 and $96/t but rose 9% by August to reach US$98-105 at year-end. The strong performance of the phosphate sector associated with a fairly balanced market led to mounting pressures on prices. In North America, higher U.S. consumption and some tightness in the U.S. sulphur supply resulted in liquid sulphur prices rising an average 17% to between US$60-70 (f.o.b. Alberta) by year-end.

The spot market was fairly quiet in 1988 as most major buyers settled through contract agreements. Spot prices ranged between US$95 and $96/t during the first half of 1988 and increased slightly to US$100-105/t in the second half.

Sulphuric acid prices in Canada rose 7% to between $65 and $75/t. Price trends were similar to those of elemental sulphur from western Canada.

USES

About 60% of all the sulphur consumed in the world is used in the production of fertilizers such as superphosphates, ammonium phosphate, and ammonium sulphate. The second largest consuming sector is the chemical industry where sulphur is used in products ranging from pharmaceuticals to synthetic fibres in plastics and petroleum catalysts. Other consumers of sulphur include the manufacture of titanium dioxide used in paint, enamels, paper, and ink; iron and steel; and nonferrous metals. These consuming industries use sulphur in the form of sulphuric acid which accounts for almost 90% of total sulphur consumption (60% of sulphuric acid consumption is in fertilizers). Products requiring sulphur in the non-acid form include insecticides and fungicides, pulp and paper, photography, leather processing, rayon, rubber, etc.

OUTLOOK

The sulphur market is in fair balance as demand is adequately met by discretionary and non-discretionary production complemented by timely stock remelts. In the short term, the market is expected to remain in balance, although declining stocks may result in upward pressure on prices. Current trade patterns are expected to prevail for some time.

Within the next three years, Canadian supply capability is likely to tighten due to the rapid depletion of vatted stocks. At the current rate of remelting, it is expected that by 1991, inventories will be limited to a few blocks with restricted availability for reasons of logistics, contamination and corporate strategies.

Canadian non-discretionary production of elemental sulphur is forecast to grow significantly over the next decade by 34% to close to 8 Mt by the year 2000. The increase will largely result from new gas related projects such as Caroline, Obed, Brazeau ... which should offset anticipated declines in sulphur production from older gas fields. Promising prospects for growth in exports of natural gas have resulted in additional exploration expenditures and new developments in gas processing since 1987.

Other sulphur producing projects associated with oil sands, petroleum refining, and heavy oil upgrading should account for 30% of the additional supply. Moreover, there is potential for higher production from super sour gas (90% H_2S) as a discretionary source of elemental sulphur. By the mid-1990s, expansions in sulphur production capability could offset the decline in Canadian supply resulting from the depletion of vatted stock, thus maintaining Canada's export capability at current levels.

The international market will undergo profound modifications over the next decade. On the supply side, production of non-discretionary sulphur should expand its market share at the expense of voluntarily produced sulphur as environmental concerns continue to increase. The U.S.S.R. is expected to emerge as a major supplier of brimstone by 1991 as export facilities become operational. Trade patterns will evolve based on logistical and commercial factors. Above ground inventories will continue to play the role of swing supplies but with a much reduced impact.

Sulphur demand is likely to remain strong in 1989 due to sustained consumption of phosphate fertilizers. The global demand for phosphates has been forecast to grow at an annual rate of 2.2% up to 1995. Phosphate consumption in developed countries is expected to grow marginally while it is anticipated to be firm in developing countries. Industrial consumption of sulphur will likely remain fairly stable. Overall world sulphur demand is forecast to grow at an annual rate of about 1.9% over the next seven years.

In the long term, the sulphur market is expected to be in close balance, depending on its availability from new sources such as the U.S.S.R. and the Middle East. Moreover, if demand for phosphates is stronger than anticipated, it may lead to greater volumes from remelts and additional developments of discretionary sulphur projects to overcome potential deficits. Growth in the supply of sulphuric acid may provide the necessary buffer to minimize the impact of brimstone shortages, in which case freight rates will become a major factor affecting established trade patterns.

TARIFFS

		Canada			United States
Item No.	Description	MFN	GPT	USA	Canada
2503	Sulphur of all kinds, other than sublimed sulphur, precipitated sulphur and colloidal sulphur				
2503.10.00	- Crude or unrefined sulphur	Free	Free	Free	Free
2503.90.00	- Other	Free	Free	Free	Free
2802.00.00	Sulphur, sublimed or precipitated; colloidal sulphur				Free
2807.00.00	Sulphuric acid; oleum	Free	Free	Free	Free
2811.23.00	-- Sulphur dioxide	Free	Free	Free	3.3%

Sources: Customs Tariffs, effective January 1989, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of United States (First Edition Supplement 2) effective January 1, 1989.

TABLE 1A. CANADA, SULPHUR SHIPMENTS AND TRADE, 1986-87

	1986		1987[1]	
	(tonnes)	($000)	(tonnes)	($000)
Shipments				
Sulphur in smelter gases[2]	758 231	72 614	783 115	89 378
Elemental sulphur[3]	6 965 775	857 584	7 322 791	660 597
Total sulphur content	7 724 006	930 198	8 105 906	749 975
Imports				
Sulphur, crude and refined				
United States	10 723	2 687	24 690	4 909
Other countries	40	9	21	6
Total	10 763	2 696	24 711	4 915
Sulphur, liquid				
United States	8 597	2 172	16 954	3 805
Total	8 597	2 172	16 954	3 805
Sulphuric acid, including oleum				
United States	19 402	2 511	37 853	3 443
West Germany	15	2	31	4
Other countries	9 710	573	6 739	299
Total	29 127	3 086	44 623	3 746
Exports				
Sulphuric acid, including oleum				
United States	755 594	25 140	803 130	25 823
Other countries	12	27	48	103
Total	755 606	25 167	803 178	25 926
Sulphur, crude or refined, n.e.s.				
United States	610 328	69 927	766 362	70 173
Brazil	479 929	91 620	546 649	79 569
Morocco	738 970	139 175	1 365 925	189 056
Tunisia	316 915	60 383	458 167	60 006
South Africa	319 803	59 249	212 099	30 119
Australia	441 916	81 392	431 774	62 077
South Korea	425 974	78 069	395 622	55 975
U.S.S.R.	848 080	158 758	60 338	9 437
India	243 848	39 356	198 308	26 936
Israel	179 796	23 835	213 509	28 876
Taiwan	228 653	40 535	165 874	21 934
Netherlands	274 957	52 662	189 875	27 577
France	89 902	17 068	92 751	14 055
New Zealand	77 419	14 272	106 033	15 218
Other countries[4]	980 564	182 572	1 368 514	194 190
Total	6 257 054	1 108 873	6 571 800	885 198

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Shipment data compiled regardless of origin (i.e. domestic and foreign source materials). [2] Sulphur in liquid SO_2 and H_2SO_4 recovered from the smelting of metallic sulphides and from the roasting of zinc-sulphide concentrates. [3] Producers' shipments of elemental sulphur produced from natural gas; also included are small quantities of sulphur produced in the refining of domestic crude oil and synthetic crude oil. [4] Mainly Belgium-Luxembourg, Italy, Senegal, Indonesia, Argentina, Chile, Cuba, and Mozambique.
n.e.s. Not elsewhere specified.

TABLE 1B. CANADA, SULPHUR SHIPMENTS AND TRADE, 1988P

		1988P	
		(tonnes)	($000)
Shipments[1]			
	Sulphur in smelter gases[2]	868 560	79 039
	Elemental sulphur[3]	8 083 400	612 871
	Total sulphur content	8 951 960	691 910
		(Jan.-Sept.)	
Imports			
2503.10	Sulphur, crude or unrefined		
	United States	2 328	453
	Total	2 328	453
2503.90	Sulphur, n.e.s.		
	United States	95 078	3 612
	Japan	9 098	255
	France	1 441	35
	Total	105 617	3 902
2802.00	Sulphur sublimed or precipitated; colloidal sulphur		
	United States	1 135 240	379
	Other countries	124 685	74
	Total	1 259 925	453
2807.00	Sulphuric acid; oleum		
	United States	23 271	2 332
	Netherlands	48	3
	West Germany	14	1
	Total	23 333	2 336
2811.23	Sulphur dioxide		
	United States	1 030	347
	Total	1 030	347
Exports			
2503.10	Sulphur, crude or unrefined		
	United States	680 647	57 245
	Morocco	1 401 458	172 992
	Tunisia	443 676	52 711
	Brazil	396 032	48 945
	Australia	373 194	43 180
	South Korea	325 977	38 745
	South Africa	307 498	37 926
	Mexico	142 748	20 322
	France	161 993	20 252
	Taiwan	135 595	17 290
	Israel	133 054	14 888
	Indonesia	123 408	14 443
	Other countries[4]	677 289	81 931
	Total	5 302 569	620 870
2503.90	Sulphur, n.e.s.		
	United States	100 561	9 057
	New Zealand	20 500	2 530
	Other countries	3 634	484
	Total	124 695	12 071

TABLE 1B (cont'd)

		1988P	
		(tonnes)	($000)
2802.00	Sulphur, sublimed or precipitated; colloidal sulphur		
	United States	2 041	339
	South Korea	1 000	720
	Total	3 041	1 059
2807.00	Sulphuric acid; oleum		
	United States	664 613	22 120
	Other countries	94	82
	Total	664 707	22 202
2811.23	Sulphur dioxide		
	United States	40 347	4 791
	Other countries	1	5
	Total	40 348	4 796

Sources: Statistics Canada; Energy, Mines and Resources, Canada.
[1] Data compiled regardless of origin (i.e. domestic and foreign source materials). [2] Sulphur in liquid SO_2 and H_2SO_4 recovered from the smelting of metallic sulphides and from the roasting of zinc-sulphide concentrates. [3] Producers' shipments of elemental sulphur produced from natural gas; also included are small quantities of sulphur produced in the refining of domestic crude oil and synthetic crude oil. [4] Mainly Belgium-Luxembourg, Italy, Senegal, Indonesia, Argentina, Chile, Cuba, and Mozambique.
P Preliminary; n.e.s. Not elsewhere specified.

TABLE 2. CANADA, SOUR GAS AND OIL SANDS SULPHUR EXTRACTION PLANTS, 1986-88

Operating Company	Source Field or Plant Location	H_2S in Raw Gas^r	Daily Sulphur Capacity 1986	1987	1988
	(Alberta, except where noted)	(percent)		(tonnes)	
Sour Gas					
Amerada Hess Corporation	Garrington - Olds	15	389	389	389
Amoco Canada Petroleum Company Ltd.	Bigstone Creek	16	382	382	385
Amoco Canada Petroleum Company Ltd.	East Crossfield-Elkton	34	1 797	1 797	1 797
Canadian Occidental Petroleum Ltd.	East Calgary	17	1 696	1 696	1 696
Canadian Occidental Petroleum Ltd.	Okotoks (Mazeppa)	36	835	577	577
Canadian Occidental Petroleum Ltd.	Paddle River	0.1	19	19	19
Canadian Superior Oil Ltd.	Harmatten-Elkton-Leduc	46	515	490	490
Canadian Superior Oil Ltd.	Lone Pine Creek	10	157	157	157
Canterra Energy Ltd.	Brazeau River-Nordegg	1.3	42	42	42
Canterra Energy Ltd.	Okotoks	34	431	431	431
Canterra Energy Ltd.	Rainbow Lake	2	139	139	139
Canterra Energy Ltd.	Ram River (Ricinus)	19	4 572	4 572	4 572
Canterra Energy Ltd.	Windfall - Whitecourt	21	1 199	1 330	1 330
Chevron Standard Limited	Kaybob South II	16	3 537	3 557	3 557
Chieftain Development Co. Ltd.	Sinclair - Hythe	3	256	256	256
Dome Petroleum Limited	W. Pembina	n.r.	294	300	340
Dome Petroleum Limited	Steelman, Sask.	1	7	7	7

TABLE 2. (cont'd)

Operating Company	Source Field or Plant Location	H_2S in Raw Gas[r]	Daily Sulphur Capacity 1986	1987	1988
	(Alberta, except where noted)	(percent)		(tonnes)	
Esso Resources Canada Limited	Joffre	3.4	17	17	17
Esso Resources Canada Limited	Quirk Creek	9	293	299	299
Esso Resources Canada Limited	Redwater	2.6	33	11	11
Gulf Canada Limited	Homeglen-Rimbey	1	128	128	128
Gulf Canada Limited	Nevis	4	295	197	197
Gulf Canada Limited	Strachan	9	943	943	953
Gulf Canada Limited	Hanlan Robb	9	1 092	1 092	1 092
Home Oil Company Limited	Carstairs	0.5	65	65	65
Hudson's Bay Oil and Gas Company Limited (HBOG)	Brazeau River	0.8	110	110	110
Hudson's Bay Oil and Gas Company Limited (HBOG)	Caroline	0.8	8	8	8
Hudson's Bay Oil and Gas Company Limited (HBOG)	Edson	1.4	284	288	289
Hudson's Bay Oil and Gas Company Limited (HBOG)	Kaybob South I	11	1 086	1 086	1 086
Hudson's Bay Oil and Gas Company Limited (HBOG)	Kaybob South II	16	1 085	1 086	1 086
Hudson's Bay Oil and Gas Company Limited (HBOG)	Lone Pine Creek	10	283	283	283
Hudson's Bay Oil and Gas Company Limited (HBOG)	Sturgeon Lake	9	98	98	98
Hudson's Bay Oil and Gas Company Limited (HBOG)	Zama	8	74	74	74
Mobil Oil Canada, Ltd.	Wimborne	13	182	182	182
Mobil Oil Canada, Ltd.	Teepee	8	30	30	30
Norcen Energy Resources Ltd.	Minnehik-Buck Lake	0.1	45	45	45
PanCanadian Petroleum Limited	Morley	5	18	0	0
Petro-Canada Inc.	Brazeau	7	80	80	444
Petro-Canada Inc.	Gold Creek	3	43	43	43
Petro-Canada Inc.	Wildcat Hills	4	177	177	177
Saratoga Processing Company Limited	Savannah Creek (Coleman)	24	389	389	389
Shell Canada Limited	Burnt Timber Creek	13	489	489	489
Shell Canada Limited	Innisfail	16	163	163	163
Shell Canada Limited	Jumping Pound	6	566	597	597
Shell Canada Limited	Progress	0.7	25	15	15
Shell Canada Limited	Rosevear	8	171	171	171
Shell Canada Limited	Simonette River	16	95	95	95
Shell Canada Limited	Waterton	19	3 148	3 107	3 107
Suncor Inc.	Rosevear	8	110	110	110
Texaco Exploration Company	Bonnie Glen	0.4	12.5	12.5	12.5
Westcoast Energy Inc.	Fort Nelson, B.C.	n.a.	1 100	1 100	1 100
Westcoast Energy Inc.	Taylor Flats, B.C.	3	460	460	460
Westcoast Energy Inc.	Pine River (Hasler Flats), B.C.	n.a.	1 055	1 055	1 055
Western Decalta Petroleum (1977) Limited	Diamond Valley	2.5	11	11	11
Oil Sands					
Suncor Inc.	Mildred Lake	n.a.	441	441	441
Syncrude Canada Ltd.	Fort McMurray	n.a.	1 155	1 155	1 255

Sources: From Alberta Energy Resources Conservation Board publications, October 1988; Oilweek, January 1986, 1987 and 1988.

[r] Revised; n.a. Not applicable; n.r. Not reported.

TABLE 3. CANADIAN PETROLEUM REFINERY SULPHUR CAPACITIES, 1986-88

Operating Company	Location	Daily Capacity		
		1986	1987	1988
			(tonnes)	
Canadian Ultramar Limited	St. Romuald, Quebec	82	40[r]	40
Chevron Canada Limited	Burnaby, British Columbia	10	10	10
Consumers' Co-operative Refineries Limited	Regina, Saskatchewan	18	16	16
Husky Oil Ltd.	Prince George, British Columbia	5	5	5
Imperial Oil Limited	Dartmouth, Nova Scotia	76	76	76
	Edmonton, Alberta	40	40	40
	Port Moody, British Columbia	20	20	20
	Sarnia, Ontario	140	140	140
Irving Oil Limited	Saint John, New Brunswick	100[r]	100[r]	100
Petro-Canada Products Inc.	Clarkson-Mississauga, Ontario	41	41	41
	Edmonton, Alberta	56	56	56
	Oakville-Trafalgar, Ontario	41	41	51
	Port Moody, British Columbia	25	25	25
Shell Canada Limited	Burnaby, British Columbia	15	15	15
	Sarnia, Ontario	31	35	35
	Scotford, Alberta	10	14	14
Sulconam Inc.	Montreal, Quebec	300	300	300
Suncor Inc.	Sarnia, Ontario	49	50	50
Texaco Canada Inc.	Nanticoke, Ontario	32	35	35
Total		1 093	1 101	1 101

Sources: Oilweek; Mineral Policy Sector, Energy, Mines and Resources Canada.
[r] Revised.

TABLE 4. CANADA, PRINCIPAL SULPHUR DIOXIDE AND SULPHURIC ACID PRODUCTION CAPACITIES, 1988

Operating Company	Plant Location	Raw Material	Annual Capacity: Liquefied SO_2	Annual Capacity: Sulphuric Acid[1]	Annual Capacity: Sulphur Equivalent[2]
			(000 tonnes)		
Brunswick Mining and Smelting Corporation Limited	Belledune, New Brunswick	SO_2 lead zinc		176	58
C-I-L Inc.	Beloeil, Quebec	Elem. sulphur		65	21
Canadian Electrolytic Zinc Limited (CEZ)	Valleyfield, Quebec	SO_2 zinc conc.		430	140
Falconbridge Limited	Sudbury, Ontario	SO_2 nickel conc.		355	116
Gaspé Copper Mines, Limited	Murdochville, Quebec	SO_2 copper		135	44
INCO Limited	Copper Cliff, Ontario	SO_2 pyrrhotite and nickel conc.		550	180
	Copper Cliff, Ontario	SO_2 copper conc.	100	-	50
Kidd Creek Mines Ltd. (amal. into Falconbridge Limited)	Kidd Creek, Ontario	SO_2 zinc conc.		220	72
	Kidd Creek, Ontario	SO_2 copper conc.		340	111
NL Chem Canada, Inc.	Varennes, Quebec	Elem. sulphur		56	18
Subtotal, Eastern Canada			100	2 327	810
Border Chemical Company Limited	Transcona, Manitoba	Elem. sulphur		150	49
C-I-L Inc.	Fort Saskatchewan, Alberta	Elem. sulphur		150	49
	Prince George, British Columbia	Elem. sulphur		35	11
Cominco Ltd.	Trail, British Columbia[3,4]	SO_2 zinc and lead conc.	75	430	206
Eldorado Resources Limited	Rabbit Lake, Saskatchewan	Elem. sulphur		72	23
Esso Chemical Canada	Redwater, Alberta	Elem. sulphur		910	297
Key Lake Mining Corporation (KLMC)	Key Lake, Saskatchewan	Elem. sulphur		72	23
Sherritt Gordon Limited	Fort Saskatchewan, Alberta	Elem. sulphur		233	75
Sulco Chemicals Ltd.	Elmira, Ontario	Elem. sulphur		33	11
Subtotal, Western Canada[5]			75	2 085	744
Total			175	4 412	1 554

Sources: Mineral Policy Sector, Energy, Mines and Resources; Canadian companies interviews; December 1988.

[1] One hundred percent H_2SO_4. [2] Elemental sulphur equivalent of sulphuric acid is 32.7% and sulphur equivalent of liquefied sulphur dioxide is 50%. [3] Cominco closed its Kimberley facilities during 1987. [4] Cominco operation at Trail has also a 28 000 t/y production capacity for elemental sulphur, which has been added to the total sulphur equivalent production capacity of Cominco. [5] Western Co-operative Fertilizers Limited mothballed its 397 000 t/y acid plant in Calgary, late in 1987.

- Nil.

TABLE 5. CANADA, SULPHUR SHIPMENTS AND TRADE, 1970, 1975 AND 1980-88

	Shipments[1]				Imports[2]	Exports[2]
	Pyrites	In Smelter Gases	Elemental Sulphur	Total	Elemental Sulphur	Elemental Sulphur
			(tonnes)			
1970	159 222	640 360	3 218 973	4 018 555	48 494	2 711 069
1975	10 560	694 666	4 078 780	4 784 006	14 335	3 284 246
1980	14 328	894 732	7 655 723	8 564 783	1 767	6 850 143
1981	5 000	783 000	8 018 000	8 806 000	4 633	7 309 216
1982	9 000	627 000	6 945 000	7 581 000	2 159	6 111 444
1983	-	678 286	6 631 123	7 309 409	2 365	5 670 275
1984	-	844 276	8 352 978	9 197 254	3 019	7 326 847
1985	-	822 359	8 102 163	8 924 522	3 167	7 848 380
1986	-	758 231	6 965 775	7 724 006	10 763	6 257 054
1987	-	783 115	7 322 791	8 105 906	24 711	6 571 800
1988[p]	-	868 560	8 083 400	8 951 960	..	..

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Shipment data compiled regardless of origin (i.e. domestic and foreign source materials).

[2] Includes only elemental sulphur in a crude or refined form.

[p] Preliminary; - Nil; .. Not available.

TABLE 6. CANADA, SULPHURIC ACID PRODUCTION, TRADE AND APPARENT CONSUMPTION, 1970, 1975, AND 1980-87

	Production	Imports	Exports	Apparent Consumption
		(tonnes - 100% acid)		
1970	2 475 070	9 948	129 327	2 355 691
1975	2 723 202	154 020	225 402	2 651 820
1980	4 295 366	18 048	323 775	3 989 639
1981	4 116 860	82 495	337 518	3 861 837
1982	3 130 854	192 514	259 740	3 063 628
1983	3 686 427	126 573	273 204	3 539 796
1984	4 043 389	28 330	553 780	3 517 939
1985	3 890 092	17 306	744 732	3 162 666
1986	3 536 062	29 127	755 606	2 809 583
1987	3 436 977	44 623	803 178	2 673 422

Sources: Statistics Canada; Energy, Mines and Resources Canada.

TABLE 7. WORLD PRODUCTION OF SULPHUR, 1985-87

	1985[r]		1986[r]		1987	
	All-forms[1]	Elemental	All-forms	Elemental	All-forms	Elemental
			(000 tonnes)			
World Total	**56 551**	**35 964**	**56 810**	**36 175**	**57 956**	**37 363**
Western World	**36 874**	**25 674**	**36 430**	**25 495**	**36 426**	**25 768**
Western Europe	**7 831**	**3 536**	**7 806**	**3 379**	**7 628**	**3 382**
Finland	520	45	577	42	627	50
France	1 723	1 546	1 318	1 138	1 243	1 063
West Germany	1 778	1 218	1 924	1 276	1 936	1 293
Italy	551	120	700	230	571	241
Norway	263	10	261	12	226	12
Spain	1 390	20	1 406	25	1 226	25
Others	1 606	577	1 620	656	1 799	698
Africa	**1 043**	**95**	**1 005**	**120**	**1 142**	**185**
South Africa	842	85	814	110	930	175
Others	201	10	191	10	212	10
Asia, Middle East	**5 642**	**3 476**	**6 087**	**3 922**	**6 110**	**4 232**
Japan	2 671	1 068	2 541	998	2 476	1 020
Saudi Arabia	1 162	1 162	1 350	1 350	1 450	1 450
Others	1 809	1 246	2 196	1 574	2 184	1 762
Oceania	**221**	**20**	**235**	**36**	**260**	**50**
North America	**19 255**	**16 152**	**18 606**	**15 609**	**18 116**	**15 238**
Canada	6 679	5 828	6 619	5 750	6 677	5 876
United States	12 576	10 324	11 987	9 859	11 439	9 362
Latin America	**2 879**	**2 395**	**2 911**	**2 429**	**3 170**	**2 681**
Mexico	2 114	2 029	2 139	2 054	2 376	2 291
Others	765	366	772	375	794	390
Eastern Europe	**6 630**	**5 150**	**6 665**	**5 130**	**6 725**	**5 175**
Poland	5 044	4 876	5 068	4 900	5 100	4 930
Others	1 586	274	1 597	230	625	245
U.S.S.R.	9 890	4 970	10 200	5 280	11 180	6 120
China	2 928	170	3 285	270	3 385	300
Other countries[2]	232	0	235	0	135	0

Source: The British Sulphur Corporation Limited, May-June 1988.

[1] All-forms includes elemental sulphur, sulphur contained in pyrites and contained sulphur recovered from metallurgical waste gases, mostly in the form of sulphuric acid. [2] Includes North Korea, Vietnam and Cuba.

[r] Revised.

TABLE 8. CANADA, SULPHURIC ACID, REPORTED CONSUMPTION BY END USE, 1986 AND 1987

	1986r	1987P
	(tonnes)	
Agricultural chemicals and fertilizers	1 652 222	1 347 767
Industrial inorganic chemicals	435 501	446 687
Uranium mines	351 821	315 445
Pulp and paper	347 806	282 595
Nonferrous smelting and refining	129 922	129 022
Other mines, metal and nonmetal	30 105	39 055
Crude petroleum and natural gas	43 138	29 689
Leather and textile	22 220	22 442
Soap and cleaning compounds	16 482	15 159
Plastics and synthetic resins	9 138	9 718
Iron and steel mills	11 524	8 867
Electrical products	17 097	7 183
Food, brewery and distillery	6 871	5 276
Other end uses	48 636	137 212

Source: Reports from producing companies compiled by Mineral Policy Sector, Energy, Mines and Resources Canada.
P Preliminary; r Revised.

Tantalum

D.G. FONG

World demand for tantalum in 1988 continued to outstrip supply, significantly drawing down processor inventories. Spurred by an increase in demand and a near doubling of prices, producers increased their output, reversing the seven-year declining trend. Supply and demand are expected to be brought into balance during 1989, with a continued strong tantalum market being matched through increases in production from tantalite mines and the recovery of tantalum-bearing tin slags.

Western world tantalum consumption in 1988 increased to an estimated 1450 tonnes (t) of tantalum pentoxide (Ta_2O_5) from the 1270 t recorded a year earlier. For the first half of 1988, the Tantalum-Niobium International Study Center (TIC) in Brussels reported a significant increase in processors' shipments to nearly all major end-users, especially for capacitor metal powders, carbides and mill products.

CANADIAN DEVELOPMENTS

Following a six-year hiatus, Tantalum Mining Corporation of Canada Limited (TANCO) resumed tantalum production in August 1988 at its Bernic Lake mine in Manitoba. By year-end, the mine was operating close to its capacity level of 113 t/y of Ta_2O_5 contained in concentrates.

Prior to resuming tantalum production, TANCO spent $4.7 million to refurbish its mine-mill complex and to complete building a lithium plant. Poor markets had led to the mine's shutdown in 1982, though operations resumed in 1986 to recover lithium. At that time, the mill's tantalum circuit was used to produce spodumene (lithium) concentrates. The mine can now produce tantalum and spodumene concentrates simultaneously.

TANCO's tantalum reserves are sufficient to maintain production at its current level for at least eight more years, while its spodumene reserves are much more extensive. During the summer months, the company intends to treat its mine tailings to produce additional tantalum concentrates. The combination of a strong tantalum market, the signing of long-term supply contracts with processors, and the simultaneous production of spodumene and tantalum will likely keep TANCO's production at near capacity levels for several years.

Highwood Resources Ltd. and Hecla Mining Company of Canada Ltd. reached an agreement in principle in 1987 to evaluate the Lake Zone deposit of the Thor Lake rare metals project, about 100 km southeast of Yellowknife in the Northwest Territories. The Lake Zone has a reported drill-indicated reserve of 70 million short tons grading 0.04% Ta_2O_5, 0.57% Cb_2O_5, 1.99% rare earth oxides, and 4.73% ZrO, making it the largest known deposit of tantalum, columbium, rare earths and zirconium in North America. The agreement will allow Hecla to earn a 50% interest in the Lake Zone.

INTERNATIONAL DEVELOPMENTS

In Australia, Greenbushes Ltd. reported production of 93 t Ta_2O_5 contained in concentrates during its fiscal year ending June 30, 1988. A planned two-step expansion will increase its annual production capacity to 155 t Ta_2O_5 in 1989 and 200 t in 1990. Production at its Bunbury operation is from the surface mining of alluvial tantalum-bearing tin deposits and the retreatment of tailings.

In the early 1980s, Greenbushes had completed development work at its adjacent underground mine, but no facilities were then installed for the treatment of the mine's hard-rock ores. An investment of $A6 million would be needed to bring this mine-mill on-stream for an additional 160 t/y Ta_2O_5 of production capacity.

During its 1987-88 fiscal year, Greenbushes also reported production of 27 t of Ta_2O_5 in upgraded forms of

---

D.G. Fong is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 992-3951.

pentoxide, carbides and metal. The pentoxide was produced at its own chemical plant at the mine site, which was restarted in February 1988. In July, the company entered into a joint venture with Austria's Treibacher Chemische Werke AG to produce and market tantalum and columbium carbides. The total production capacity of the carbides is about 70 t/y.

Pancontinental Mining Ltd., has announced its intention to recover tantalum from its Wodgina deposit in the northwest corner of Western Australia. Production from this source will likely add another 45 t/y of Ta_2O_5 to the Australian output.

In Brazil, the Paranapenema SA plans to begin commercial production of tantalum in early 1989 at its new processing plant at Pirpora, near Sao Paolo. Production in 1989 will be between 45 t to 90 t of Ta_2O_5, with ores being derived from its Pitinga tin mine in the Amazon. The mine also has a capability of producing 910 t of columbium pentoxide.

Companhia de Estanho Minas Brasil of the Metallurg Group, the largest tin producer in the world, operates a tin-tantalite mine in the state of Minas Gerais, Brazil. The mine has an annual tantalum production capacity of 45 t of Ta_2O_5 in concentrates, which are converted into oxide form at the adjacent chemical plant and further processed at other Metallurg plants abroad.

Gesellschaft für Elektrometallurgie mbH of the Metallurg Group restarted its tin-slag upgrading plant in Weisweiler in late 1988. The Elektrowerk Weisweiler plant, which had been shut down since August 1986, processes low-grade tantalum-bearing tin slags into synthetic concentrates from which tantalum metal can be produced. Metallurg is one of the two companies in the world that can upgrade low-grade tin slags, the other being Hermann C. Starck Berlin, also of West Germany.

The Thailand Tantalum Industry Corporation (TTIC) plans to build a new US$35 million tantalum plant in the Mabtaphut district of southern Rayong province, Thailand. TTIC has been granted a financial package by the Thai government, including a US$18 million 10-year soft loan, and US$5 million in equity for a 19.6% interest of the project. The new plant will replace TTIC's southern Phuket operation that was destroyed by arson in 1986. Its destruction even before startup stemmed from environmental concern that pollution from the plant would destroy the island's tourist industry.

TTIC expects its new plant will be completed in the second half of 1990; annual production capacity will be 300 t of combined Ta_2O_5 and Cb_2O_5, using tin slags as feeds.

USES

Tantalum is a refractory metal with unique physical, electrical and chemical properties that make it useful in a number of industrial applications, including electronics, carbide making, chemical equipment and high temperature alloys.

The electronics industry is by far the largest user of tantalum, accounting for 45-50% of world demand. Tantalum is the preferred metal for electronic capacitor anodes because of its inertness and the stability of its electrolytic oxide film. Tantalum capacitors are used in all forms of electronic systems such as computers, communication systems and military applications where compactness and reliability are key factors. About 5.3 billion units were shipped worldwide in 1988.

Tantalum cemented-carbides are used mainly in mixtures with other carbides such as tungsten, titanium, columbium, chromium, vanadium, molybdenum and hafnium. The addition of tantalum carbide to other metallic carbides imparts a greater cratering resistance, as well as the ability to be machined at much higher cutting-edge temperatures. Cemented carbides are used in tools for cutting, turning, and boring, and in wear-resistant parts and dies.

At low to moderate temperatures, tantalum's high resistance to corrosion by most acids and its inertness to many chemicals has made it the preferred material for severe environments, particularly for thin-sheet linings in chemical equipment.

Tantalum is an important additive in special nickel- and cobalt-base superalloys that are used in high-temperature applications such as jet engines and gas-turbine parts. The addition of tantalum increases the strength of these superalloys and improves the high-temperature performance in terms of fuel efficiency and durability. Pratt & Whitney Group, subsidiary of United Technologies Corp. is using a high-tantalum content single-crystal superalloy, PW1480, for its jet engines. The single-crystal technology has been licensed to the U.S. government for applications in the space-shuttle program.

PRICES

The spot market tantalite price rose steadily from US$24-$28/lb. of Ta_2O_5 contained in concentrate at the beginning of 1988 to US$49-$51 by year-end. TANCO continued to suspend publication of its tantalite price. In February 1988, Greenbushes Ltd. of Australia recommenced publishing its producer price, set at US$32/lb. of Ta_2O_5 contained in concentrate, subsequently increasing its price in three stages to US$47-$50/lb. by September.

OUTLOOK

The tantalum market is expected to remain strong in 1989. Demand by the electronic capacitor sector is expected to continue to rise particularly in unit shipments. However, because of rising raw-material costs, the total tantalum required will not match the unit-shipment increases because of the trend of using smaller units and higher charge tantalum powders. Moreover, the revolution in circuit board to surface-mount technology using moulded chips, and the recent advances in multi-layer ceramic capacitors, will have some negative impact on the increased uses of tantalum.

In the superalloy sector, reported demand growth has not risen as fast in 1988 as in the previous year, but consumption is likely to continue increasing. More usage of single-crystal turbines blades (12% Ta) in jet engines and record orders for new aircraft to replace ageing fleets are positive indicators for rising tantalum consumption.

High energy armour-penetrators and shape-charge warheads for use in anti-tank warfare offer promising growth prospects for tantalum alloys. The high-temperature strength, good ductility and high density of tantalum enable self-forging on impact by the projectile. Successful development of this application, which is still in an early stage, could lead to another major market for tantalum.

TARIFFS

Item No.	Description	Canada MFN	Canada GPT	Canada USA	United States Canada
2615.90.00.20	Tantalum ores and concentrates	Free	Free	Free	Free
81.03	Tantalum and articles thereof, including waste and scrap				
8103.10	- Unwrought tantalum, including bars and rods obtained simply by sintering; waste and scrap; powders				
8103.10.10	--- Unwrought tantalum, not alloyed; powders, not alloyed	4%	Free	3.2%	2.9%
8103.10.20	--- Unwrought tantalum, alloyed; waste and scrap; powders, alloyed	10.2%	6.5%	8.1%	2.9%
8103.90.00	- Other	10.2%	6.5%	8.1%	4.4%

Sources: Customs Tariffs, effective January 1989, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States (First Edition Supplement 2) effective January 1, 1989.

TABLE 1A. CANADA, TANTALUM PRODUCTION, TRADE AND CONSUMPTION, 1975 AND 1980-87

	Production[1]	Imports		Consumption
		Primary Forms and Fabricated Metals		Ferrocolumbium and Ferro-tantalum-columbium,
	Ta_2O_5 Content	Tantalum	Tantalum Alloys	Cb and Ta-Cb Content
		(kilograms)		
1975	178 304	..	..	215 910
1980	115 261	21 280	12 112	486 251
1981	103 949	2 769	5 043	455 500
1982	59 276	1 759	1 146	356 000
1983	-	1 742	332	359 000
1984	-	4 489	1 499	482 000
1985	39 457	2 370	1 354	447 000
1986	38 846	2 137	1 918	438 000
1987	x	16 341	3 211	574 000P

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Producers' shipments of tantalum ores and concentrates and primary products, Ta_2O_5 content.

- Nil; .. Not available; x Confidential; P Preliminary.

TABLE 1B. CANADA, TANTALUM PRODUCTION AND TRADE, 1988P

Item No.		1988P	
		(kilograms)	($000)
Production[1]		x	x
Imports		(Jan.-Sept.)	
2615.90.00.20	Tantalum ores and concentrates		
	United States	14 075	20
	Total	14 075	20
81.03	Tantalum and articles thereof, including waste and scrap		
8103.10	- Unwrought tantalum, including bars and rods obtained simply by sintering; waste and scrap; powders		
8103.10.10	-- Unwrought tantalum, not alloyed; powders, not alloyed		
	United States	879	603
	Total	879	603
8103.10.20	-- Unwrought tantalum, alloyed; waste and scrap; powders, alloyed		
8103.10.20.20	--- Waste and scrap		
	United States	17 000	729
	Taiwan	1 409	170
	Zaire	10 779	161
	Belgium	687	57
	United Kingdom	483	41
	Total	30 359	1 158
8103.90.00	- Other		
	United States	29 544	2 454
	Puerto Rico	207	13
	Total	29 752	2 467
Exports			
81.03	Tantalum and articles thereof, including waste and scrap		
8103.10	- Unwrought tantalum; including bars and rods obtained simply by sintering; waste and scrap; powders		
	United States	250 417	338
	Japan	314	36
	Brazil	200	22
	Total	250 931	396
8103.90	- Other		
	United States	1 705	294
	Total	1 705	294

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Producers' shipments of tantalum ores and concentrates and primary products, Ta_2O_5 content.

P Preliminary; x Confidential.

Note: Numbers may not add to totals due to rounding.

Tin

D. AUDET

Tin prices, expressed in U.S. dollars, increased by about 5% in 1988. Mine production increased significantly with new low cost production from independent Brazilian tin prospectors, the garimpeiros. Elsewhere, tin mine production changed very little. Metal consumption increased slightly during 1988 as tin plating became more cost competitive in the canning industry due to stable tin prices and higher aluminum prices. Legal action against the International Tin Council (ITC) continued and the ITC ceased its statistical functions. In March 1988, the Association of Tin Producing Countries (ATPC) renewed its tin rationalization scheme which limits the exports of its members in order to maintain tin markets in equilibrium.

SUPPLY: CANADIAN DEVELOPMENTS

Canadian tin mine production is from one open-pit mine located in East Kemptville, Nova Scotia. Early in 1988, Rio Algom Limited bought back the mine it had originally developed and opened in 1985. In 1986, Rio Algom wrote-off its investment because of the collapse of tin prices, and ownership reverted to the creditor banks which maintained operation under Rio Algom management. Rio Algom announced that a flotation circuit will be built in 1989 to improve its tin recovery rates. The mine contains an orebody originally estimated at 56 Mt grading 0.163% with low grades of copper and zinc.

Tin by-product recovery by Kidd Creek Mines Ltd. in Timmins (which amalgamated into Falconbridge Limited in 1988) and Cominco Ltd. at Kimberley was not resumed in 1988. Lac Minerals Ltd. completed an exploration project in 1987 at Mount Pleasant, New Brunswick, but Lac Minerals has not announced its intentions concerning this site. At Buchans, Newfoundland, the Duck Pond copper, zinc and tin deposit is under active exploration. As a by-product in the production of indium, Cominco produces a small quantity of tin-lead alloy at its smelter in Trail. The alloy is used for solder applications.

Canada relies on imports for its tin metal requirements except for small amounts recovered from recycled solders, detinning and Cominco's tin-lead alloy production. Consumption has been remarkably stable since 1984. Refined tin is imported by two large Canadian steelmakers, Stelco Inc. and Dofasco Inc., for producing tin plate for use primarily in can production.

SUPPLY: WORLD DEVELOPMENTS

Brazil

An important development in tin has been the emergence of Brazil as the world's largest tin mine producer with an estimated mine production of 44 000 t/y. The discovery of large cassiterite ores almost on the surface of the ground in the remote Rondonia state of Brazil has created the equivalent of a "gold rush" for tin. Within months, it has been estimated by "Metal Bulletin" that more than 18 000 persons became tin prospectors-extractors, the so-called garimpeiros. The garimpeiros have formed cooperative entities which then sell to tin companies. Under Brazilian law, individual mining operations are illegal but cooperatives are not. The bulk of the cassiterite tin concentrates is trucked to Sao Paulo state, 3 500 km away. Despite the distance, smelters can produce tin metal economically.

Brazil is not a member of the ATPC but has agreed to cooperate in limiting its exports to a level determined in consultation with the ATPC. The agreement with the ATPC is implemented by Cacex, the foreign trade Department of the Banco do Brasil, which allocates allowable exports to companies. The export control policy has forced domestic smelters to compete more aggressively for the domestic market and has also kept the Brazilian smelting capacity

---

D. Audet is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 992-4409.

underutilized. While Brazilian tin consumption rose sharply in 1988 to about 7 000 t from 5 500 t in 1987, "Metal Bulletin" reported that domestic market prices are 15-20% below free market levels. At current rates of mine production, a large surplus of concentrates will be accumulated unless export restrictions are lifted shortly or the export quotas are increased significantly in 1989. The presence of large inventories may work as a disincentive to tin mine production despite the low extraction costs and the lack of alternative employment for the garimpeiros.

The Association of Tin Producing Countries

The ATPC began a supply rationalization scheme in March 1987 with the objective of accelerating the absorption of the huge tin stock overhang caused by the cessation of the buffer stock operations of the International Tin Council, and to prevent further price declines. The scheme involved the establishment of an overall export quota of 96 000 t for the 12 months beginning in March 1987 and divided among its seven members, i.e. Malaysia, Indonesia, Thailand, Bolivia, Australia, Zaire and Nigeria. Brazil and China, although non-members, have also cooperated in limiting their exports to 21 000 t and 7 000 t, respectively. In March 1988, it was estimated by ATPC that the stock overhang had been reduced from 73 000 t to 47 000 t. The export restrictions were renewed for another twelve-month period ending in March 1989 at a level of 101 900 t for ATPC members, 26 500 t for Brazil and 10 000 t for China. Over the period, the rate of depletion of the stocks slowed considerably, to an estimated 44 000 t at the end of 1988.

The ATPC argues that its rationalization scheme is the primary factor in the reduction of the stock overhang in 1987-88 but depressed prices have also helped to limit production.

There is evidence that some ATPC members have had difficulties in meeting their increased export quotas in 1988-89. For example, in Malaysia mine output declined by about 2 000 t in 1988 and dropped by 30% between 1983 and 1988. Malaysian mines have generally survived the 1986-87 period by mining higher grade tin deposits. In Bolivia, attempts to re-open the largest mine, Huanuni, closed since the end of 1986, were frustrated by a three-month strike and technical problems at the new ore processing plant. Bolivia was criticized by other ATPC members for having permitted Brazil to use 2 000 t of its unused quota.

ATPC agreed to continue its export controls for a third year beginning in March 1989, but had to concede a 5 000 t increase to Brazil in exchange for its cooperation. The new export limits for ATPC members total 106 400 t, up from 101 900 t in 1988-89. Brazil's export limit will be 31 500 t but China's is unchanged at 10 000 t.

Other Tin Producers

In Portugal, the Neves Corvo open-pit copper mine was opened in December. The large copper deposit also includes an estimated 2.8 Mt of tin ore grading 2.6%, which is likely to yield 5 000 t of tin in concentrates in 1990 and up to 10 000 t/y when copper production reaches full capacity. As a by-product of copper, tin will be recovered at low cost. The mine was developed by Sdad Minera de Neves-Corvo (Somincor), owned 51% by the state-run Empresa de Desenvolvimento Mineiro EP and 49% by RTZ Corporation PLC. Somincor invested $60 million in a tin concentrator. This new source of tin, insensitive to prevailing tin prices, is likely to delay the reopening of higher cost tin operations closed following the price collapse in 1986.

In the United Kingdom, RTZ's Capper Pass smelter announced a major reorganization program involving a reduction in electrolytic tin capacity from 22 000 t/y to about 10 000 t. Capper Pass will now specialize in treating lower grade and complex primary and secondary materials. It expects to produce 10 000 t/y of premium grade of electrolytic tin from 45 000 t/y of raw materials. Capper Pass produced 17 800 t of refined tin in 1987. Tin concentrates from the East Kemptville mine in Nova Scotia were treated at the smelter until early 1988 but are now smelted in Mexico and elsewhere.

Information on China's tin industry is sparse and there are uncertainties as to whether tin exports achieved in recent years can be sustained in the future. On the one hand, domestic demand for nonferrous metals and steel has been strong and domestic frustrations from the manufacturing sectors against metal deliveries led to the imposition of export restrictions against scarce materials including copper and its alloys, aluminum and its alloys, nickel and its alloys, nickel products, platinum and yellow phosphorus. On the other hand, China needs foreign currencies to sustain its expanding import requirements and to offset its losses of foreign exchanges on banned exports. The recent decision of China to abide to an unchanged 10 000 t export limit under the ATPC rationalization scheme for 1989-90 reflects the lack of mine capacities in the short term to serve both an expanding domestic market and export market.

In the United States, the operational management of the national defense stockpile has been shifted from the General Services Administration (GSA) to the Defense Logistics Agency (DLA), an arm of the Pentagon. The U.S. President's executive order, delegates to the Pentagon most of the functions authorized under the Strategic and Critical Materials Stockpiling Act. In 1988, the GSA did not sell tin directly but traded tin to two metal processing firms in return for upgrading certain ores for the GSA stockpile. The goal for the stockpile is 42 674 t, compared with holdings of about 174 000 t in September 1988. The ATPC, as part of its rationalization scheme, has urged the United States to restrict releases of tin from its strategic stockpile.

INTERNATIONAL ORGANIZATIONS

The Sixth International Tin Agreement

The Sixth International Tin Agreement (ITA) is an international producer/consumer arrangement aimed at stabilizing the price of tin mainly through the operation of a buffer stock and by selective use of export controls. The Sixth ITA entered provisionally into force on July 1, 1982, under the direction of the International Tin Council (ITC). On October 24, 1985, the ITC ran out of funds and defaulted on loans and contracts. Since then, the ITC's creditors have taken various legal actions against the ITC and its members in the United Kingdom and elsewhere. The ITC continued to collect and disseminate tin statistics and information on tin markets until June 1988.

International Tin Study Group

With the demise of the ITC, interest has been expressed by major producers and consumers in the establishment of a group which would perform statistical functions but would not have any market intervention power. Under the auspices of UNCTAD, a Tin Conference was convened in late November to negotiate the establishment of an intergovernmental producer/consumer forum for tin which would have as a primary objective the collection and the dissemination of tin statistics. The Conference focussed its attention on draft terms of reference for such a group. While significant progress was achieved on many provisions, differences of opinion still exist as to whether the group should be an autonomous body, like the International Lead and Zinc Study Group, or whether it should be within the auspices of UNCTAD. Discussions will resume in March 1989.

Research Organizations

The International Tin Research Institute is entrusted with the task of maintaining and extending the use and effectiveness of tin in modern technology. It is financed by the governments of five of the major tin producing countries: Indonesia, Malaysia, Nigeria, Thailand and Zaire. Its headquarters and laboratories are in Uxbridge, Middlesex, England.

The South East Asia Tin Research and Development (SEATRAD) Centre is a regional organization established by the governments of Indonesia, Malaysia and Thailand, with assistance from the Economic and Social Commission for Asia and the Pacific (ECAP) and other United Nations agencies. The purpose of the Centre is to promote, conduct and coordinate research and training in relation to the technical and economic aspects of exploration, mining, mineral processing and smelting of tin. The Centre's headquarters and laboratories are located in Ipoh, Malaysia. In addition to the work being conducted in the laboratory, field projects are maintained in various member countries in southeast Asia. The Centre is financed by equal contributions from member countries.

USES

Tinplate traditionally has been the largest use of tin. Tinplate use in the canning industry has been under severe competitive pressures from aluminum. Also, thinner tin coatings on food and beverage cans have reduced consumption of tin for tinplate. However, with the recent increase in aluminum prices and low and relatively stable tin prices, tinplate has improved its cost competitive position. Tinplate competition also comes from non-tin coated steels, tin-free steel (TFS) or electrolytic chromium coated steel (ECCS). In the United States, aluminum has taken over the large metal beverage container market. Similarly, the increasing popularity of the microwave oven has food producers examining alternate packaging materials including plastics and cellulose.

Solder is another traditional use of tin. In the United States and in Japan it may soon surpass tinplate as the largest market for tin. Strong growth in the electronics industry has provided a new impetus for this tin use. Growth in tin solder is however limited by the trend towards the use of less solder per assembly. This trend is more evident in the increasing use of surface mounted components which permits greater solder savings. A growing trend in North America, due to regulatory actions, is to replace standard lead-tin solder in water pipes with silver-tin solder. This would increase tin consumption in solder, since the latter is comprised 95% of tin versus about 50% in the former.

The fastest growing new use for tin has been in chemical applications. Tin is used in an array of inorganic and organic chemicals, for application as P.V.C. stabilizers, agricultural pesticides, anti-fouling paints for ships and biocidal compounds for the protection of materials such as paints, textiles and building materials.

Tin is also used for tinning (which includes electronic uses, hot dipping and electroplating in the electronics industry), in the manufacture of pewterware, and in bronze, brass and other tin-containing alloys. Tin-containing alloys are used in construction, machinery and equipment and consumer durables.

Tin consumption grew slightly in 1988 due to the improved cost competitiveness of tinplate, the health considerations related to lead solder for water pipes and the growing chemical applications for tin. Consumption is expected to continue to improve in 1989.

PRICES AND STOCKS

Tin prices increased slightly in U.S. dollars in 1988, with the average price on the European free market rising from US$3.10 to 3.25.

The tin market was in a deficit again in 1988. Western world metal supply minus net exports to socialist countries is estimated at 156 000 t. Western world tin consumption is estimated at 168 000 t, leaving a deficit of 12 000 t. The deficit for 1987 was 18 000 t, suggesting that 30 000 t of tin stocks have been absorbed over the last two years.

ATPC figures indicated that world stocks fell from 73 000 t in March 1987 to 47 800 t in March 1988 and 44 000 t at the end of December 1988. However, stocks are expected to fall only to 43 900 t by the end of February 1989 due to additional supply from Brazil. ATPC has increased its total export limits by 9 500 t for the 1989-90 period. Given relatively slow growth in consumption it seems doubtful that stocks will decline by 8 000 t during 1989-90 as anticipated by the ATPC. Notwithstanding the small reduction in the overall stocks, tin stocks on the LME fell to 5 775 t at the end of 1988 from about 20 000 t in January. This large reduction can be explained by increased holdings by consumers attracted by low tin prices.

The Kuala Lumpur Commodity Exchange (KLCE) began trading tin futures contracts in October 1987. The KLCE is attempting to fill a nest left empty by the suspension of trading on the LME when the ITC ran out of funds in October 1985. Trading on the KLCE has been quiet not so much because of technical reasons related to the high cost of using the market, or doubts about the security of the clearing system or time differences between Malaysia and Europe, but primarily because of lack of interest in hedging. Tin prices have been virtually stable for two years now. Resumption of trade on the LME is being reviewed regularly but it seems unlikely that trading will resume until legal claims against the ITC are resolved. Brazil's Bolsa Mercantil e de Futuros is considering launching a tin futures market in 1989.

OUTLOOK

Tin prices are expected to remain fairly stable in 1989, hovering within a range of US$3.30 to $3.60. The tin market was in equilibrium at the end of 1988 and the 9 500 t increase in export limits agreed among ATPC members, Brazil and China for the twelve-month period starting in March 1989 suggests that metal supply will likely exceed consumption unless some tin producers effectively export less than their allocated quota.

In 1989, mine output is expected to increase in Brazil, Malaysia, Indonesia and Portugal. Metal production is also expected to increase significantly, particularly in Brazil and Indonesia. Metal production should however fall significantly in the United Kingdom with the rationalization program at the Capper Pass smelter. Tin consumption is likely to continue to grow at a slow rate given the positive prospects in the major tin end-uses. The competitive position of tinplate, in particular, has improved relative to aluminum for food and beverage cans.

In the early 1990s, the tin market is expected to be adequately supplied with additional mine output, particularly from low cost production in Portugal. The spirit of cooperation between ATPC members, Brazil and China is expected to decline as tin producers are becoming more concerned about their market shares in an excess supply market environment. The emergence of major new producers with differing interests outside of southeast Asia (Brazil and Portugal) is reducing the industry's geographical concentration and cohesiveness.

Longer term prospects for tin consumption are not buoyant. Tin in chemicals offers the best prospects but consumption of tinplate is likely to continue to fall slowly in the longer term.

TARIFFS

Item No.	Description	Canada MFN	Canada GPT	Canada USA	United States Canada	EEC MFN	Japan[1] MFN
2609.00.00.00	Tin ores and concentrates	Free	Free	Free	Free	Free	Free
7204.30.00.00	-Waste and scrap of tinned iron or steel	Free	Free	Free	Free	Free	Free
8001.10.00.00	-Tin, not alloyed	Free	Free	Free	Free	Free	Free
8001.20	-Tin alloys						
8001.20.10.00	---Tin-antimony alloys	Free	Free	Free	Free	Free	3.2%
8001.20.20.00	---Tin-lead-antimony alloys	6.8%	Free	Free	Free	Free	3.2%
8001.20.90.00	--Other	10.2%	6.5%	Free	Free	Free	3.2%
8002.00.00.00	Tin waste and scrap	Free	Free	Free	Free	Free	Free
8003.00	Tin bars, rods, profiles and wire						
8003.00.10	---Bars and rods, not alloyed or of tin-antimony alloys	Free	Free	Free	3.3%	3.2%	3.7%
8003.00.10.10	-----Not alloyed	Free	Free	Free	3.3%	3.2%	3.7%
8003.00.30.00	---Bars and rods, of phosphor-tin alloys	5.5%	3.5%	4.4%	3.3%	3.2%	3.7%
8003.00.50.00	---Bars and rods, of other alloys; profiles; other wire	10.2%	6.5%	8.1%	3.3%	3.2%	3.7%
8004.00	Tin plates, sheets and strip, of a thickness exceeding 0.2 mm						
8004.00.20.00	---Of phosphor-tin alloys	5.5%	3.5%	4.4%	1.9%	2.5%	3.7%
8004.00.90	---Other	10.2%	6.5%	8.1%	1.9%	2.5%	3.7%
8004.00.90.10	-----Not alloyed	10.2%	6.5%	8.1%	1.9%	2.5%	3.7%
8004.00.90.20	-----Of tin-antimony alloys	10.2%	6.5%	8.1%	1.9%	2.5%	3.7%
8004.00.90.90	-----Other	10.2%	6.5%	8.1%	1.9%	2.5%	3.7%
8005.20	-Powders and flakes						
8005.20.10.00	---Powders, not alloyed	4%	Free	3.2%	3.3%	2.9%	4.9%
8005.20.20.00	---Alloyed powders, flakes	10.2%	6.5%	8.1%	3.3%	2.9%	4.9%
8006.00.00.00	Tin tubes, pipes and tube or pipe fittings (i.e., couplings, elbows, sleeves)	10.2%	6.5%	8.1%	1.9%	4.5%	4.9%
8007.00.00	Other articles of tin	10.2%	6.5%	9.1%	2.7% to 3.7%	5.3%	5.8%
8007.00.00.10	-----Anodes for electroplating	10.2%	6.5%	9.1%	2.7%	5.3%	5.8%

Sources: Customs Tariffs, effective January 1989, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States (First Edition Supplement 2) effective January 1, 1989; Official Journal of the European Communities, Vol. 30, No. L256, 1987, "Conventional" column; Custom Tariff Schedules of Japan, 1988.

[1] GATT rate is shown, lower tariff rates may apply circumstantially.

NOTE: Where there is a tariff "range" a complete match of the HS code was not available, therefore, the high and low for the product in question is shown.

TABLE 1A. CANADA, TIN PRODUCTION, TRADE AND CONSUMPTION, 1985-87

	1985		1986		1987	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Production						
Tin content of tin concentrates and lead-tin alloys	119	2 057	x	x	x	x
Exports						
Tin in ores, concentrates and scrap[1]						
United Kingdom	100	292	1 763	13 780	2 423	25 354
Mexico	139	925	77	662	215	1 141
United States	102	619	1 887	416	50	277
Malaysia	-	-	-	-	90	95
Hong Kong	17	5	-	-	-	-
Total	358	1 841	3 727	14 857	2 778	26 867
Tinplate scrap						
United States	3 326	390	522	99	590	99
India	38	11	-	-	-	-
Hong Kong	-	-	102	28	-	-
France	15	1	-	-	-	-
Total	3 379	403	624	127	590	99
Imports						
Blocks, pigs, bars						
United States	1 074	17 273	1 495	14 862	1 788	16 146
Brazil	1 401	22 632	966	9 429	801	7 261
People's Republic of China	-	-	-	-	253	2 303
Australia	12	168	-	-	240	2 124
Indonesia	40	635	180	1 355	220	1 936
Other countries	1 169^r	18 604^r	1 284^r	11 139^r	490	4 352
Total	3 696	59 311	3 925	36 785	3 792	34 121
Tinplate						
West Germany	54	34	-	-	2 124	1 713
United States	480	579	4 402	4 898	876	998
United Kingdom	-	-	2	2	3	2
Spain	-	-	89	59	-	-
Greenland	-	-	17	17	-	-
Total	534	613	4 510	4 976	3 003	2 713
Tin, fabricated materials, n.e.s.						
United States	304	1 363	397	1 747	389	1 674
West Germany	8	46	10	26	39	134
United Kingdom	14	107	10	38	26	110
Hong Kong	1	6	11	46	5	29
Taiwan	-	5	5	24	3	24
Other countries	3^r	21^r	2^r	26^r	4	25
Total	330	1 547	435	1 907	466	1 996
Consumption[2]						
Tinplate and tinning	2 492	..	2 300	..	2 486	..
Solder	1 029	..	938	..	1 035	..
Babbit	74	..	179	..	153	..
Bronze	285	..	176	..	273	..
Other uses (including collapsible containers, foil, etc.)	86	..	62	..	57	..
Total	3 966	..	3 655	..	4 004P	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Tin content of ores and concentrates plus gross weight of tin scrap. [2] Available data as reported by consumers.

^{r} Revised; .. Not available; - Nil; n.e.s. Not elsewhere specified; x Confidential.

Note: Components may not add due to rounding.

TABLE 1B. CANADA, TIN PRODUCTION AND TRADE, 1988P

Item No.		1988P	
		(tonnes)	($000)
Production			
Tin content of tin concentrates and lead-tin alloys		x	x
Exports		(Jan.-Sept.)	
2609.00	Tin ores and concentrates		
	United Kingdom	1 665	15 322
	Malaysia	490	2 157
	Mexico	275	1 413
	Total	2 430	18 892
7204.30	Waste and scrap of tinned iron or steel		
	United States	11 654	1 699
	Thailand	570	142
	South Korea	532	93
	Other countries	796	198
	Total	13 552	2 132
8001.20	Tin alloys unwrought		
	United States	91	652
	United Kingdom	...	4
	Total	91	656
8002.00	Tin waste and scrap		
	Pakistan	477	271
	United States	150	72
	United Arab Emirates	17	37
	Total	644	380
8005.20	Tin powders and flakes		
	South Korea	900	32
	Other countries	110	1
	Total	1 010	33
Imports			
8001.10.00.00	Tin, not alloyed, unwrought	3 136	26 857
8001.20	Tin alloys unwrought		
8001.20.10.00	Tin-antimony alloys	75	553
8001.20.20.00	Tin-lead antimony alloys	2	15
8001.20.90.00	Other	26	236
8003.00	Tin bars, rods, profiles and wire		
8003.00.10.10	Bars and rods, not alloyed	15	130
8003.00.30.00	Bars and rods, of phosphor-tin alloys	1	10
8003.00.50.00	Bars and rods, of other alloys; profiles; other wire	8	114
8004.00	Tin plates, sheets and strip, of a thickness exceeding 0.2 mm		
8004.00.20.00	-of phosphor-tin alloys	3	9
8004.00.90	-Other		
8004.00.90.10	--Not alloyed	...	3
8004.00.90.20	--Of tin-antimony alloys	3	41
8004.00.90.90	--Other	16	133
8005.20.00	Powders and flakes		
8005.20.10.00	Powders, not alloyed	14	156
8005.20.20.00	Alloyed powders, flakes	1	9
8006.00.00.00	Tin tubes, pipes and tube or pipe fittings (i.e., couplings, elbows, sleeves)	1	40
8007.00.00.10	Other articles of tin - anodes for electro-plating	2	19

Source: Statistics Canada.
P Preliminary; x Confidential; ... Too small to be expressed.

TABLE 2. CANADA, TIN PRODUCTION, EXPORTS, IMPORTS AND CONSUMPTION, 1970, 1975 AND 1980-87

	Production[1]	Exports[2]	Imports[3]	Consumption[4]
		(tonnes)		
1970	120	268	5 111	4 565
1975	319	1 052	4 487	4 315
1980	243	883	4 527	4 517
1981	239	513	3 791	3 766
1982	135	601	3 235	3 528
1983	140	371	3 769	3 371
1984	209	315	4 105	4 076
1985	119	358	3 696	3 966
1986	x	3 727	3 925	3 655
1987	x	2 778	3 792	4 004P

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Tin content of tin concentrates shipped plus tin content in lead-tin alloys produced. [2] Tin in ores and concentrates and tin scrap, and re-exported primary tin. [3] Tin metal. [4] Current coverage exceeds 90%, whereas until 1972, coverage was in the order of 80 to 85%; available data as reported by consumers.
P Preliminary; x Confidential.

TABLE 3. WORLD[1] TIN PRODUCTION, CONSUMPTION AND PRICES, 1970, 1975 and 1980-88

	Production			Prices	
	Tin in Concentrate	Primary Metal	Consumption	Malaysia[2]	NY Dealer[3]
			(000 t)		
1970	185	185	185	10.99	1.74
1975	181	179	173	15.94	3.40
1980	201	198	174	35.72	7.73
1981	205	197	163	32.34	6.48
1982	190	180	157	30.09	5.86
1983	172	159	155	30.19	6.01
1984	167	161	165	29.16	5.67
1985	158	155	160	29.69	5.25
1986	139	148	165	15.49	2.94
1987e	139	159	166	16.83	3.15
1988e	156	168	168	..	3.31

Sources: International Tin Council, 1970-86; Energy, Mines and Resources Canada, 1987 and 1988.
[1] Excludes countries with centrally planned economies, except Bulgaria, Czechoslovakia, Hungary, Poland, Romania and Yugoslavia. [2] Cash price ex-smelter for Grade A tin, shipment within 60 days, in Malaysian ringgits per kg, the ringgit being the unit used to define price levels under recent International Tin Agreements. [3] "Metals Week", U.S. dollars per pound.
e Estimate; .. Not available.

TABLE 4. WORLD[1] CONSUMPTION OF PRIMARY[2] TIN, 1970 AND 1985-88

	1970	1985	1986	1987e	1988e
			(tonnes)		
EEC, total[3]	58 246	38 285	41 799	42 004	..
West Germany	14 062	15 668	16 884	16 978	..
France	10 500	6 900	7 461	7 359	..
United Kingdom	16 951	6 000	6 000	6 200	..
Netherlands	5 467	4 253	4 009	4 246	..
Italy	7 200	5 000	4 560	4 800	..
Belgium/Luxembourg	3 000	920	1 141	1 220	..
United States	53 807	37 136	32 548	35 597	37 500
Japan	24 710	31 594	31 521	32 425	33 000
Spain	3 040	3 100	2 600	2 600	..
Poland	..	3 029	3 624	2 824	..
Brazil	2 139	4 644	5 875	5 500	7 000
Canada	4 565	3 966	3 655	4 004	..
Czechoslovakia	3 420	2 800	3 200	3 200	..
Republic of Korea	394	2 600	4 335	4 000	..
Australia	3 837	2 600	2 460	2 600	..
Total, including Others	184 800	159 600	165 100	165 700	168 000

Source: International Tin Council, 1970-86; Energy, Mines and Resources Canada, 1987 and 1988.

[1] Excludes countries with centrally planned economies, except Bulgaria, Czechoslovakia, Hungary, Poland, Romania and Yugoslavia. [2] May include secondary tin in some countries.

[3] Includes all 1982 members in all years except Greece in 1970.

.. Not available; e Estimate.

TABLE 5. WORLD[1] PRODUCTION OF TIN-IN-CONCENTRATES, 1970 AND 1985-88

	1970	1985	1986	1987e	1988e
			(tonnes)		
Malaysia	73 794	36 884	29 134	30 845	28 760
Indonesia	19 092	21 758	24 634	26 321	27 500
Bolivia	30 100	16 136	10 479	8 000	9 500
Thailand	21 779	16 593	16 792	15 305	15 000
Brazil	3 610	26 514	25 449	28 500	44 000
Australia	8 828	6 934	8 470	7 500	7 700
United Kingdom	1 722	5 200	4 345	3 200	3 000
South Africa	1 986	2 193	2 055	1 673	1 600
Peru	20	3 807	4 817	5 202	5 200
Zaire	6 458	2 177	1 889	1 900	1 900
Total, including Others	184 900	158 200	139 200	138 900	155 642

Sources: International Tin Council, 1970-86; Energy, Mines and Resources Canada, 1987 and 1988.

[1] Excludes countries with centrally planned economies, except Czechoslovakia, Poland and Hungary.

e Estimate.

TABLE 6. WORLD[1] PRODUCTION OF PRIMARY TIN METAL, 1970 AND 1985-88

	1970	1985	1986	1987^e	1988^e
			(tonnes)		
Malaysia	91 945	45 500	43 788	44 776	45 000
Indonesia	5 190	20 418	22 080	27 000	27 800
Thailand	22 040	17 996	19 672	16 407	17 000
Bolivia	300	11 400	7 673	5 000	5 000
Brazil	3 100	24 703	25 104	28 500	35 500
United Kingdom	22 035	7 548	9 227	17 800	16 800
Netherlands	5 937	5 308	5 114	4 004	4 000
Australia	5 211	1 421	1 399	600	700
Spain	3 908	3 291	1 725	1 961	2 000
United States	4 540	3 000	3 213	3 900	4 000
South Africa	1 491	2 056	1 816	1 608	1 600
Singapore	..	5 308	500	1 000	1 000
Nigeria	8 069	1 027	91	644	600
Total, including Others	184 900	155 400	148 000	159 100	168 100

Sources: International Tin Council, 1970-86; Energy, Mines and Resources Canada, 1987 and 1988.

[1] Excludes countries with centrally planned economies, except Czechoslovakia, Poland and Hungary.

.. Not available; ^{e} Estimate.

TABLE 7. MONTHLY AVERAGE TIN PRICES[1], 1987 AND 1988

	N.Y. Dealer US$/lb.		Malaysia US$/lb.		Europe Free Market[2] US$/lb.	
	1987	1988	1987	1988	1987	1988
January	3.16	3.18	3.04	3.08	3.11	3.16
February	3.16	3.15	3.03	3.03	3.09	3.10
March	3.15	3.19	3.01	3.07	3.09	3.13
April	3.17	3.19	3.04	3.06	3.12	3.11
May	3.19	3.22	3.06	3.07	3.13	3.13
June	3.14	3.31	3.00	3.19	3.06	3.21
July	3.03	3.35	2.90	3.24	2.97	3.29
August	3.12	3.43	2.97	3.32	3.05	3.37
September	3.16	3.45	3.04	3.36	3.10	3.39
October	3.18	3.39	3.07	3.29	3.12	3.33
November	3.24	3.42	3.14	3.32	3.19	3.38
December	3.18	3.43	3.10	3.33	3.16	3.39
Yearly average	3.15	3.31	3.03	3.20	3.10	3.25

Source: "Metals Week".

[1] Prices are for Grade A (in the United States) or High Grade (99.85% tin or more).

[2] Rotterdam warehouse.

Titanium and Titanium Dioxide

D.E.C. KING

World demand for titanium raw materials and titanium dioxide pigment remained strong during 1988, as it had throughout the previous four years. Producers operated at nearly full capacity in attempting to satisfy the demand. New plant capacity was brought on-stream, and there were announcements of new projects planned and in progress.

CANADA

The main Canadian titanium-based industries comprise ilmenite mining and smelting and titanium oxide pigment production. Other more minor activities include titanium metal fabrication of finished parts, coating of welding rods, and the manufacture of titanium carbide and nitride coated parts. In addition, titanium-bearing master alloys are used to make special steel and aluminum alloys. The mining, smelting and pigment operations are carried out exclusively in Quebec, whereas the downstream activities are located in several provinces. Canada does not have any capacity for producing primary titanium (in the form of sponge or granules) or ferrotitanium. Some capacity for vacuum melting, forging and rolling exists in Canada.

QIT-Fer et Titane Inc. (QIT) is the only company that mines titanium ore in Canada. Ilmenite, a mineral containing somewhat more iron than titanium, is mined at Lac Allard, Quebec. The raw ore is shipped to Tracy, Quebec, where it is beneficiated, and the concentrate is smelted to produce high quality pig iron and titania (TiO_2) slag (Sorelslag), which is used as feedstocks by titanium dioxide pigment producers. In mid-1987, The British Petroleum Company p.l.c. (BP) through its subsidiary BP Minerals International Ltd. acquired control of The Standard Oil Company (Sohio), which owns Kennecott Corporation and QIT. However, in late 1988, BP had offered its minerals unit for sale to RTZ Corporation PLC.

The slag produced from ilmenite mined at Lac Allard, Quebec by QIT is suitable as feedstock for titanium dioxide pigment produced by the sulphate process. In recent years, plants based on this process have been closed down for environmental reasons, and replaced by chloride process plants requiring higher quality slag. Because of BP's major shareholding in Richards Bay Minerals (RBM) of South Africa, QIT is able to supply 85% TiO_2 slag from RBM to the chloride process market.

QIT's $130 million expansion of its Lac Allard ilmenite mining and Tracy smelting operations in Quebec, which will increase its capacity by 175 000 t/y of 80% TiO_2 slag and 150 000 t/y of high purity pig iron, was completed in mid-1988. The project included the refurbishment of two electric furnaces and the upgrading of the plant's water, gas and electrical systems. The expansion will raise QIT's total production capacity to about 1.025 Mt/y of 78-80% slag.

In April 1986, QIT entered into a joint venture partnership with the Madagascar government's Office Militaire Nationale pour les Industries Strategiques (OMNIS) to develop beach-sand deposits containing high grade ilmenite. The initial exploration and feasibility studies were subsequently expanded and continued through 1988. Subject to a decision to proceed, plans call for QIT Madagascar Minerals et Cie to begin mining the deposits in 1993. The mining rate under consideration is 600 000 t/y of ilmenite, some of which would be smelted at Tracy, Quebec to produce 90% TiO_2 slag. The balance of ilmenite would be marketed to sulphate plants without further processing. The slag would be suitable for both types of pigment plants. Large reserves of heavy minerals have been outlined in three adjacent areas: Mandena, Petriky and St. Luce near Fort Dauphin in southeast Madagascar. The sands contain

---

D.E.C. King is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 992-3733.

about 5% heavy minerals containing ilmenite, rutile, zircon and monazite in the approximate ratio 60/3/3/1, respectively. Wet and dry concentration pilot tests have yielded high recoveries and concentrate grades.

Most of QIT's output of Sorelslag is exported to the United States and Europe, and approximately 10-15% is sold in Canada to two pigment producers, NL Chem Canada, Inc. at Varennes, and Tioxide Canada Inc. at Tracy, Quebec. Both pigment producers employ the sulphate process and both plants were at full capacity in 1988 each with output exceeding 36 000 t/y of TiO_2.

The new chloride process pigment plant announced by NL Chem Canada, Inc. in 1985 began to be commissioned in November 1987. It almost reached its full production capacity of 42 000 t/y by the end of 1988. Alternative feedstocks for its plant are RBM 85% TiO_2 slag supplied by QIT, natural rutile or synthetic rutile. Feedstock supplies at some future date could include 90% TiO_2 slag smelted from Madagascar ilmenite.

In recent years, chloride processes for producing pigment have been replacing sulphate plants that have been closed down for environmental reasons. Chloride plants produce less waste products because the chlorine reagent is recycled and generally use higher grade feedstocks.

The total Canadian consumption of titania pigment, is about 80 000 t/y. Some grades of pigment are imported, the total amounting to about 27 700 t in 1987. About one half of all of Canadian production is exported, mainly to the United States.

Notwithstanding the prevailing trend away from the sulphate process, there were further announcements of sulphate plant expansions in 1988. In addition, industry has been actively addressing the environmental problem of acidic sulphate wastes by examining neutralization and acid recycle alternatives. In Canada, a pilot plant based on a process owned by Chemetics Ltd. and financed jointly by QIT, NL and Tioxide, was constructed adjacent to Tioxide's pigment plant in Sorel, Quebec. Testing began in 1987 and had reportedly met all technological performance and cost objectives before the end of 1988. The process totally evaporates dilute acidic sulphate effluent to sulphate solids, and concentrates the acid to over 90% H_2SO_4 for recycle. A roaster would convert the sulphates to a small mass of oxides for disposal while increasing overall recovery of sulphuric acid for recycled sulphur dioxide.

The Canadian pigment companies have been able to increase production to a marginal extent with their existing sulphate process plants by upgrading unit operations to remove bottlenecks. Further expansions have not been announced but both companies are likely to install plants for waste-acid recycle or neutralization over the near term in order to meet new environmental regulations.

Shop scrap from the small number of Canadian companies that make finished products from imported titanium forgings, castings, bar, pipe, tube, plate and sheet is sold to U.S. producers of ferrotitanium. The total amount of titanium forgings, castings and bar stock consumed by companies producing for aerospace is about 300 t/y.

The quantities of titanium used in making chemical equipment and airframes in Canada vary widely, but appear to be in the order of 50 to 150 t/y for chemical equipment and 10 to 50 t/y for aircraft parts.

The quantities of titanium added as ferrotitanium and composite master alloys to specific grades of steels are small compared with some alloying elements. Canada imported about 460 t titanium content of such additives in 1986 and about 400 t in the first nine months of 1987. By comparison, the quantities of titanium added to aluminum alloys are of a much smaller order: possibly about 10 t/y of titanium in 5-10% titanium-aluminum master alloys.

Canadian companies that produce wear-resistant parts utilizing titanium nitrides and carbides for the mining and other industries use very small amounts of titanium, which are not separately reported in statistics.

WORLD DEVELOPMENTS

Titanium Minerals

Ilmenite, an iron titanate, is the source for 90% of the world supply of titanium dioxide pigment production. The more expensive rutile, a titanium dioxide mineral, is sometimes used by the chloride segment of the pigment industry and is generally favoured by producers of primary titanium metal. Anatase, another titanium dioxide mineral, exists in large quantities in Brazil and may become another important feedstock after technological problems are overcome.

Titaniferous slag and synthetic rutile, which are produced by different processes from ilmenite, are high-grade feedstocks that are growing in prominence.

Titanium Dioxide Pigment

Approximately 93% of all titanium ore mined is used to produce pigment while titanium metal accounts for about 5%. The demand for titanium pigment intensified throughout 1988. Some consumers were reportedly paying high spot prices to obtain supplies.

As a result of mergers and acquisitions over recent years, there are now four major world pigment producers: E.I. du Pont de Nemours and Company (du Pont); Tioxide International Ltd. (Tioxide); NL Chemicals, Inc. (NLC); and SCM Corporation (SCM). Pigment is produced by two alternative methods known respectively as the sulphate and chloride processes. Environmental concerns led to the closure of sulphate plants in the early 1980s but this type of operation still accounts for about 55% of the total western world pigment production of about 2.9 Mt.

Titanium Metal

A flat market for titanium metal products existed throughout 1986 and the first half of 1987, despite large orders for commercial aircraft and low metal prices. However, an upsurge in orders for commercial aircraft was largely responsible for an 11% increase in demand in 1988, and this segment accounted for about 60% of all U.S. consumption. The industrial demand for titanium had also strengthened, with some authorities predicting a higher proportion of industrial usage and greater replacement of alloy steel by titanium.

Developments by Country

Australia: CRA Limited released details of a large sand deposit of heavy minerals near Horsham in Victoria. About 1 billion tonnes have been outlined containing 3% heavy minerals and nearly 5 billion tonnes at 2% cut-off grade. The heavy minerals were reported to contain approximately 48% ilmenite, 13% rutile/anatase, 17% leucoxene, 19% zircon, 2% monazite and 0.6% xenotime. Evaluation of the deposit is being carried out by Wimmera Industrial Minerals Pty Limited, a subsidiary of CRA. The minerals are fine-grained, which may limit mineral separation recovery. The company is basing its evaluation on about 500 000 t/y production of heavy minerals.

Mining operations are scheduled to begin in late 1989 at the Cooljarloo mineral sands deposit at Cataby north of Perth, Western Australia, by the two joint venture partners, TiO_2 Corporation NL and Kerr-McGee Chemical Corporation. The deposit has reserves of 569 Mt of sand containing 3.2% heavy minerals comprising ilmenite, zircon, leucoxene and monazite in the ratio 60/4/11/9/1, respectively. Mining is to be carried out with a 1600 t/h dredge and wet concentrator, to produce 700 000 t/y wet concentrate from which will be separated 400 000 t/y ilmenite, 35 000 t/y rutile, 60 000 t/y zircon and 1 000 t/y monazite. The joint venture plans to construct a 330 000 t/y synthetic rutile plant to start up in mid-1990 and a 54 000 t/y chloride process pigment plant for later production.

At Eneabba, a deposit containing 150 Mt of sand with 4% heavy minerals has been outlined by Consolidated Gold Fields PLC 5 km west of its existing operations. Potential is 210 000 t/y ilmenite, 40 000 t/y rutile, 70 000 t/y zircon and 2 500 t/y of monazite for at least 12 years. A feasibility study is under way that would enable a production decision by mid-1989. Another study has been initiated to evaluate, by July 1989, the construction of a 125 000 t/y synthetic rutile plant using ilmenite from the new deposit.

Tioxide Australia Pty. Ltd. has been expanding the capacity of its sulphate process pigment plant at Burnie, from 36 000 t to 52 000 t, which is scheduled for completion in 1990/91.

United States: Pigment capacity is to be increased by E.I. du Pont de Nemours and Company (du Pont) at its De Lisle, Miss., chloride process titanium dioxide pigment plant. Installation of a second production line of 100 000 t/y capacity will bring total production capacity at De Lisle to 270 000 t/y, raising du Pont's world total to 800 000 t/y. This new expansion is due for completion in late 1990.

Kerr-McGee Chemical Corporation announced that it is expanding its pigment capacity at Hamilton, Miss., from 78 000 t/y to 96 000 t/y, with a planned mid-1989 start.

A new greenfield operation with a capacity of 82 000 t/y pigment is to be constructed by NL Chemicals, Inc., at Lake Charles, Louisiana by 1991.

The Savannah, Georgia, plant of Kemira Inc., is also being expanded by the construction of a 45 000 t/y chloride process titanium dioxide plant to be brought on-stream in late 1989.

SCM Chemicals Ltd. is adding 16 500 t/y to its Ashtabula chloride process plant. The new plant should be in operation by the end of 1989.

United States metal companies, which have enjoyed a competitive edge over European and Japanese companies aided by favourable currency exchange rates, have also been active. RMI Company of Niles, Ohio, is planning to expand titanium sponge capacity from about 8 800 to 9 500 t/y by mid-1989. Oregon Metallurgical Corporation (OREMET) was reported to be planning an expansion in two stages from about 4 100 to 5 400 t/y of sponge by the end of 1989. Both integrated firms have been producing sponge at full capacity.

OREMET's ingot capacity was reduced to two thirds of its 7 250 t/y total, from mid-year to November, because of a compacting press failure.

Brazil: du Pont pulled out of its proposed joint venture with Construtora Andrade Gutierrez SA to construct a 60 000 t/y titanium dioxide pigment plant, and later announced that it would build a plant independently through its Brazilian subsidiary Du Pont do Brazil. du Pont is currently seeking government approval for the plant, which would be located in Uberaba and subject to supply of feedstock from the proposed 200 000 t/y anatase concentrate plant of Companhia Vale do Rio Doce (CVRD), which is planned to begin operating in 1992/93.

West Germany. Vereinigte Schmiedewerke, a new company formed by Krupp Stahl AG, Klöckner Stahl & Thyssen Stahl AG will be carrying out titanium activities through Deutschen Titanium. The Thyssen, Krefeld plant of 2 200 t/y is to be closed down and all titanium production will take place in the 2 500 t/y Krupp plant. Both plants had been operating at less than 50% capacity.

Italy: A new titanium sponge plant of 5 000 t/y capacity is to be built and on-stream by October 1989 at Terni, north of Rome. The plant will be owned by IRI Group, an Italian steel conglomerate. It will use the technology developed by Elettrochimica Marco Ginatta (EMG), which will receive royalties.

Belgium: A new chloride process pigment plant to be built by NL Chemicals SA, a subsidiary of NL Industries, Inc., is due to start production at the end of 1989. The plant will replace the existing sulphate process plant.

New Zealand: The development of a 350 000 t/y ilmenite mine by Fletcher Titanium Products Ltd. is to be preceded by a 10 000 t/y pilot mine to come on-stream in mid-1989. Fletcher is also planning a 3 000 t/y titanium dioxide pilot plant for a 1991 start up.

Malaysia: Tioxide Group plc announced that it is studying the possible installation of a pigment plant using ilmenite produced from tin tailings. Trengganu is a possible site.

Mozambique: The joint venture of Kenmare Resources PLC and the Geological Survey of Yugoslavia has reassessed reserves of mineral sands near Angoche on the northeast coast. Reserves now stand at 124 Mt with 4% heavy minerals containing 83.6% ilmenite, 8.1% titanomagnetite, 4.4% zircon, 2.6% rutile and 1.3% monazite.

Cameroon: Rutile deposits are under study by the Cameroon government and a French government agency. If feasible, a 20-40 000 t/y mining operation may be implemented. The deposits are estimated to contain about 200 000 t of rutile.

Senegal: du Pont has agreed to explore and possibly mine titanium-bearing beach sand deposits on Senegal's coast.

PRICES

Producer prices of ilmenite rose 7-12% to A$75-$90/t during the year, while rutile prices increased 2.5-6% to A$585-$635/t.

Published prices for titanium dioxide pigment increased by 3-4.5% in 1987.

After several years of depressed prices, all titanium metal product prices rose during 1988. U.S. sponge producers returned to profitability in 1988 although this was apparently not true for products in Europe and Japan.

TECHNOLOGICAL DEVELOPMENTS

The earlier development of slag and synthetic rutile feedstocks from relatively abundant ilmenite reserves enabled the supply of higher grade feedstocks to pigment plants. The higher grade feeds resulted in lower quantities of waste products and often higher plant capacity and lower costs. Slag and synthetic rutile could often be used in place of the ever scarcer and more expensive natural rutile.

Recently, Solv-Ex Corp. of Alberquerque, New Mexico, announced that it is seeking financing to test a process to separate bitumen and titanium and other minerals from Athabasca Tar Sands.

In the pigment industry, environmental regulations have led to the closure of sulphate process plants and their replacement by chloride process plants. This has led to recent developmental efforts by firms like Chemetics Ltd. to develop waste acid treatment processes that may restore the sulphate pigment process to its former level of acceptance as a viable method of producing pigment.

With a view to developing more efficient processes to produce titanium sponge, Albany Titanium, Inc. of the United States and Elettrochimica Marco Ginatta (EMG) of Italy were both active in process development on a pilot scale. The EMG process, which utilizes fused salt electrolysis in one of its stages, is to be further developed both in the United States by RMI and in Italy, where IRI is to build a 5 000 t/y commercial plant. The fused salt electrolysis would be operated continuously in contrast to the existing batch Hunter and Kroll processes, and is projected to save 30% of energy input. However Albany's efforts to develop a process based on fluosilicate leaching terminated near the end of 1988 with the announcement, that its assets are to be liquidated.

OUTLOOK

The depletion of natural rutile supply will continue to encourage the conversion of ilmenite to titaniferous slag and synthetic rutile to meet the rising demand for high grade feedstocks. Anatase may also enter the market to help fill this demand. Production plans for feedstocks of all kinds are progressing to meet the demand from pigment plants. The present insufficiency of supply of pigment and consequent higher pigment prices have resulted in announcements of capacity expansions by all of the major pigment producers. If all of these projects are completed on time, they should provide an adequate, if tight, supply over the next three years.

TARIFFS

Item No.	Description	Canada MFN	Canada GPT	Canada USA	United States Canada	EEC MFN	Japan[1] MFN
2614.00.00.00	Titanium ores and concentrates	Free	Free	Free	4%	Free	Free
2823.00.00.00	Titanium oxides	10% BPT Free	Free	9%	5.4%	6%	6%
3206.10.00.10	-Pigments and preparations based on titanium dioxides	10% BPT Free	Free	8%	4.8%	..	4.8%
7202.91.00.00	--Ferrotitanium and ferrosilico-titanium	10.2%	6.5%	8.1%	2.9%	4.9%	3.7%
8108.10	Titanium and articles thereof, including waste and scrap						
8108.10.10	---Unwrought titanium, not alloyed; powders, not alloyed	4%	Free	3.2%	Free	5%	5.1%
8108.10.20	---Unwrought titanium, alloyed; waste and scrap; powders, alloyed	10.2%	6.5%	8.1%	..	..	5.1%
8108.90.00	-Other						
8108.90.10	-----Bars and rods, not alloyed	10.2%	6.5%	9.1%	..	Free	6.5%
8108.90.20	-----Plates, sheets, strip and foil, not alloyed	10.2%	6.5%	9.1%	..	..	6.5%
8108.90.30	-----Anodes	10.2%	6.5%	9.1%	4.9%	7%	6.5%
8108.90.40	-----Tubes and pipes, not alloyed	10.2%	6.5%	9.1%	..	..	6.5%
8108.90.50	-----Castings	10.2%	6.5%	9.1%	..	7%	6.5%
8108.90.90	-----Other	10.2%	6.5%	9.1%	..	7%	6.5%

Sources: Customs Tariffs, effective January 1989, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States (First Edition Supplement 2) effective January 1, 1989; Official Journal of the European Communities, Vol. 30, No. L256, 1987, "Conventional" column; Custom Tariff Schedules of Japan, 1988.

[1] GATT rate is shown, lower tariff rates may apply circumstantially.

.. Not available or not applicable.

TABLE 1A. CANADA, TITANIUM PRODUCTION AND TRADE, 1985-87

	1985		1986		1987	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Production (shipments)						
Titanium dioxide, slag	x	x	x	x	x	x
Exports[1] to the United States						
Titanium metal, unwrought, including waste and scrap	133^{r}	550	243^{r}	756^{r}	144	379
Titanium metal, wrought	353^{r}	8 578	362^{r}	8 731^{r}	351	9 430
Titanium dioxide	24 183	40 991	22 235	39 565^{r}	15 905	28 314
Titanium slag	177 110^{r}	49 636	176 046	49 597	199 004	55 194
Imports						
Titanium in ores and concentrates						
Australia	340	150	119	59	16 321	7 282
United States	1 619	1 147	2 775	1 065	2 101	1 471
Norway	-	-	-	-	889	119
United Kingdom	-	-	...	-	...	-
Total	1 959	1 297	2 894	1 124	19 311	8 872
Titanium dioxide, anatase						
United States	2 657	4 705	1 563	3 313	4 721	9 645
West Germany	5 502	7 229	5 273	8 421	4 044	7 383
France	903	1 389	263	475	365	745
Belgium-Luxembourg	324	471	508	846	303	560
People's Republic of China	88	98	-	-	319	556
Netherlands	-	-	5	12	83	244
Other countries	3 565^{r}	5 303^{r}	252^{r}	447^{r}	313	494
Total	13 039^{r}	19 195^{r}	7 864^{r}	13 513^{r}	10 148	19 627
Titanium dioxide, rutile						
United States	6 862	11 622	10 424^{r}	19 203^{r}	12 570	24 338
United Kingdom	407	658	702	1 276	445	877
Austria	-	-	52	85	-	-
Belgium-Luxembourg	350	506	54	112	48	135
Denmark	-	-	12	35	-	-
Other countries	4 987^{r}	7 389^{r}	8 586^{r}	16 167^{r}	7 405	14 569
Total	12 607^{r}	20 175^{r}	19 830^{r}	36 878^{r}	20 468	39 919
Titanium metal						
United States	479	15 110	377^{r}	15 341^{r}	317	11 064
Japan	72	734	54	633	66	898
United Kingdom	25	573	40	808	9	682
Belgium-Luxembourg	8	831	8	865	1	71
Other countries	5^{r}	262^{r}	1^{r}	60	-	29
Total	589	17 511	480^{r}	17 707^{r}	392	12 745
Ferrotitanium[2]						
United States	288	1 153	230	915	152	566
United Kingdom	100	373	213	859	394	1 117
West Germany	-	-	...	2	...	5
Italy	-	-	18	84	-	-
Total	388	1 526^{r}	461	1 860^{r}	545	1 688

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] U.S. Department of Commerce, U.S. General Imports, Report F.T. 135 and United States Department of the Interior, Minerals Yearbook. Canadian export statistics do not provide separate categories. [2] Total alloy weight.
^{r} Revised; - Nil; ... Amount too small to be expressed; x Confidential.
Note: Totals may not add due to rounding.

TABLE 1B. CANADA, TITANIUM PRODUCTION AND TRADE, 1988P

Item No.		1988P	
		(tonnes)	($000)
Production (shipments)			
Titanium dioxide, slag		x	x
		(Jan.-Sept.)	
Exports			
2614.00	Titanium ores and concentrates		
	Japan	74 591	3 727
	West Germany	53 332	3 721
	Italy	18 029	2 112
	United States	24 478	1 906
	Austria	27 689	1 297
	Brazil	9 650	1 069
	United Kingdom	18	2
	Total	207 788	13 834
2823.00.00	Titanium oxides		
	United States	19 087	29 372
	United Kingdom	58	164
	France	38	103
	Dominican Republic	40	95
	Hong Kong	18	29
	Japan	...	2
	Total	19 241	29 765
3206.10.00	-Pigments and preparations based on titanium dioxide		
	United States	4 743	9 839
	France	18	66
	Japan	18	42
	United Kingdom	8	37
	Total	4 787	9 984
81.08	Titanium and articles thereof, including waste and scrap		
8108.10	-Unwrought titanium; waste and scrap; powders		
	Japan	25	586
	United States	88	428
	United Kingdom	48	226
	India	13	30
	South Korea	...	8
	Total	174	1 278
8108.90	-Other		
	United States	89	1 853
	Belgium	3	94
	Other countries	2	91
	Total	94	2 038
Imports			
2614.00	Titanium ores and concentrates		
	Australia	19 228	9 490
	United States	1 045	1 011
	Norway	2 013	125
	Yugoslavia	17	61
	Total	22 304	10 687

TABLE 1B. (cont'd)

Item No.		1988P Jan.-Sept. (tonnes)	1988P Jan.-Sept. ($000)
Imports (cont'd)			
2823.00.00	Titanium oxides		
	United States	4 352	9 375
	West Germany	1 707	4 267
	France	688	2 155
	United Kingdom	497	1 530
	Netherlands	368	1 390
	Australia	503	1 098
	People's Republic of China	549	1 071
	Other countries	558	1 737
	Total	9 222	22 623
3206.10.00	-Pigments and preparations based on titanium dioxide		
	United States	7 711	15 205
	West Germany	234	611
	Australia	253	569
	France	271	470
	Netherlands	81	278
	Italy	84	183
	Other countries	144	316
	Total	8 778	17 632
7202.91.00	--Ferrotitanium and ferrosilico-titanium		
	United States	446	976
	United Kingdom	101	486
	Total	547	1 462
81.08	Titanium and articles thereof, including waste and scrap		
8108.10	-Unwrought titanium; waste and scrap; powders		
	United States	250	2 491
	Japan	30	328
	Other countries	2	73
	Total	282	2 892
8108.90	-Other		
	United States	782	20 909
	Japan	112	2 120
	United Kingdom	16	732
	Belgium	5	629
	Other countries	14	168
	Total	929	24 558

Sources: Energy, Mines and Resources Canada; Statistics Canada.
P Preliminary; x Confidential; ... Too small to be expressed.

TABLE 2. PRODUCTION OF ILMENITE CONCENTRATE BY COUNTRIES, 1984-87

	1984	1985	1986^{P}	1987^{e}
	(000 tonnes)			
Australia[1]	1 525	1 433	1 252	1 075
Canada[2]	726	844	850	900
Norway	650	736	804	852
U.S.S.R.^{e}	440	445	450	454
Republic of South Africa[3]	417	435	435	649
United States[1]	249^{e}	290	270	270
India	150	143	140	140
Finland	167	127	-	-
China	140	140	140	140
Malaysia	268	315	415	500
Sri Lanka	102	115	100	100
Brazil	41	76	75	75
Total	4 875	5 099	4 931	5 155

Sources: U.S. Bureau of Mines, Minerals Yearbook Preprint, 1987; U.S. Bureau of Mines, Mineral Commodity Summaries, 1987/88.

[1] Australian Mineral Industry Annual Review 1987. [2] Titanium slag containing 70-71% TiO_2 to end of 1983; 80% TiO_2 after 1983. [3] Titanium slag containing 85% TiO_2.
^{P} Preliminary; ^{e} Estimated; - Nil.

TABLE 3. PRODUCTION OF RUTILE BY COUNTRIES, 1984-87

	1984	1985	1986^{P}	1987^{e}
	(000 tonnes)			
Australia[1]	170	212	216	249
Sierra Leone	91	81	97	113
Republic of South Africa	56	55	55	55
United States[1]	30	30	30	30
Sri Lanka	6	9	7	7
U.S.S.R.	10	10	10	10
India^{e}	6	7	7	7
Total	369	404	422	471

Sources: U.S. Bureau of Mines, Minerals Yearbook Preprint; U.S. Bureau of Mines, Mineral Commodity Summaries.

[1] Australian Mineral Industry Annual Review 1987.
^{P} Preliminary; ^{e} Estimated.

Tungsten

H.L. MARTIN

Canada, which until 1985 was the world's third largest producer of tungsten contained in ores and concentrates, has not recorded any mine production since 1986. At that time, low tungsten prices forced the closure of Canada's last producer, the Cantung mine of Canada Tungsten Mining Corporation Limited, in the Northwest Territories. Continuing low prices for tungsten have led to the shutdown of more than 60 tungsten mines throughout the world during the past six years, leaving the People's Republic of China and the U.S.S.R. as the world's dominant tungsten sources, with the People's Republic of China alone now accounting for some 70% of world trade.

The decade-long slump in world production of tungsten contained in ores and concentrates appears to have bottomed out in 1987. Estimated 1988 world production of 39 000 t is about 3% above the 1987 figure of 37 886 t, the low-point of the decade. Projected 1988 world consumption of 44 000 t is some 5% greater than the 42 046 t recorded in 1987. The excess of consumption over production implies that world inventories are being drawn down. Estimates of production and consumption for 1989 show little change compared to 1988, and the overall outlook for the tungsten market appears to be improving as demand is slowly growing while supply is restrained.

CANADIAN CONSUMPTION

Canada's 1988 consumption of tungsten in its various product forms is estimated to be little changed from the 765 t recorded in 1987. Consumption in 1989 should remain essentially at the same level, reflecting the anticipated continuing high level of exploration and development activities by Canada's mining industry and the resulting brisk demand for tungsten-containing drill bits.

Canada has no facilities for converting tungsten ores and concentrates into tungsten's main intermediate product, ammonium paratungstate (APT). APT is then converted to produce ferrotungsten (used to make high-speed and tool and die steels, superalloys and nonferrous alloys), tungsten metal and carbide powders (used to make cemented carbides for tools and drilling bits), and tungsten chemicals (used as catalysts). Tungsten consumption in Canada is almost exclusively in the form of carbide. Main users in Canada are Macro Division of Kennametal Inc. at Port Coquitlam, British Columbia; Kennametal Ltd. at Victoria, British Columbia; Canada Carboloy Inc. at Toronto, Ontario; and Teledyne Canada Firth Sterling Ltd. at Brantford, Ontario.

INTERNATIONAL EVENTS

The key international highlights for 1988 relate to events in the People's Republic of China, the world's dominant producer and exporter, and in the two major consumer regions, the United States and the European Economic Community (EEC). To these events may be added the formal inauguration in February 1988 of a new trade association, the International Tungsten Industry Association (ITIA), formed to serve the interests of both producers and consumers of tungsten.

To stabilize and improve tungsten markets, the People's Republic of China established a Chamber of Export of Tungsten Ores and Products, which introduced a stringent licensing system for tungsten exports. In September 1988, the People's Republic of China hosted the Fifth Meeting of Government Representatives of Tungsten-Producing/Exporting Countries, where Canada attended as an observer. At this meeting, the People's Republic of China made a commitment to implement a minimum producer price structure for concentrates and ammonium paratungstate by March 31, 1989. Although no other participant made a similar commitment, the People's Republic of China took this lead in the hope that others would not undercut these minimum prices.

H.L. Martin is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 992-3731.

For the United States, the Orderly Marketing Agreement (OMA), concluded by the United States in 1987 with the People's Republic of China, introduced changes to the market in the mix of tungsten-containing materials imported during 1988. The OMA limits U.S. imports of APT and tungstic acid (TA) from the People's Republic of China until October 1991, but places no cap on other tungsten forms, such as concentrates or scrap. The 1988 quota for APT and TA was set at 862 000 lbs. of tungsten content, well below the 3.5 million lbs. imported by the United States from the People's Republic of China in 1987. However, the People's Republic of China more than made up for the limitation by increasing its exports to the United States of tungsten concentrates, ferrotungsten and tungsten scrap, which were expected to total some 12 million lbs. of tungsten content in 1988. The new prominence of the People's Republic of China as a supplier of tungsten to the United States is illustrated by its rising share of U.S. imports, from under 5% in 1983, to 30% in 1986, and to 40% in 1987, to about 48% in 1988. Thus, despite the current high level of U.S. consumption, estimated by the U.S. Bureau of Mines at 10 044 short tons of tungsten content for 1988, the North American tungsten mining industry has not been able to capitalize on this upsurge. It remains almost entirely shut down due to low tungsten prices and the increasing amounts of tungsten supplied by the People's Republic of China.

Within the countries comprising the EEC, production of tungsten products of all types has declined sharply and has almost disappeared in the case of ferrotungsten. The Commission of the European Communities, in response to claims by its industry that the People's Republic of China and North Korea were "dumping" tungsten products onto the EEC market, stated in December 1988 that it would launch an investigation into these allegations.

UNCTAD COMMITTEE ON TUNGSTEN

The failure of tungsten to find significant new outlets, despite the rapid expansion of industrial sectors utilizing tungsten products, prompted the Committee on Tungsten (COT) of the United Nations Conference on Trade and Development (UNCTAD) to undertake a new approach to its market-stabilization initiatives. At its November 1988 meeting in Geneva, COT decided to focus its activities on improved market transparency. It will be improving its statistical coverage and information on tungsten production, processing, trade, consumption, competition from substitutes, and structural changes. The new attitude by COT reflects the growing tendency of producers and consumers to seek stability in commodity markets through the creation of international study groups.

PRICES

Prices for tungsten concentrates in 1988 averaged some 15% higher than those in 1986 and 1987, reflecting the improved demand for tungsten materials. Metal Bulletin's average price for wolframite was US$56/mtu (7.93 kg W) in 1988, compared to US$49 and US$48 in 1987 and 1986, respectively.

USES

World tungsten consumption is concentrated in four areas: tools for metalworking, which account for well over half of world demand; the transportation equipment section; the mining equipment industry and the construction industry. These four areas have expanded in response to the growing world economies, but technological progress is leading to pressures that reduce the use of tungsten. For example, the greater use of coatings is prolonging tool life; downsizing and near-net shape techniques in metal fabrication are leading to lower tool requirements; and new materials such as ceramics and cermets (ceramic-metal composites) in tools are now competitors.

TARIFFS

Item No.	Description	Canada MFN	Canada GPT	Canada USA	United States Canada
2611.00	Tungsten ores and concentrates	Free	Free	Free	Free
2841.80	Tungstates (wolframates)	9.2%	6%	7.3%	8%
2849.90	Other carbides, whether or not chemically defined (includes tungsten carbide)	Free	Free	Free	8.4%
7202.80	Ferro-tungsten and ferro-silico-tungsten	10.2%	6.5%	8.1%	4.4%
81.01	Tungsten (wolfram) and articles thereof, including waste and scrap				
8101.10	- Powders				
8101.10.10	--- Not alloyed	4%	Free	3.2%	8.4%
8101.10.20	--- Alloyed	10.2%	6.5%	8.1%	8.4%
	- Other:				
8101.91	-- Unwrought tungsten, including bars and rods obtained simply by sintering; waste and scrap				
8101.91.10	--- Sintered bars and rods, not alloyed	Free	Free	Free	5.2%
	--- Other:				
8101.91.91	---- Unwrought tungsten, not alloyed	4%	Free	3.2%	5.2%
8101.91.92	---- Unwrought tungsten, alloyed; waste and scrap	10.2%	6.5%	8.1%	3.3% to 5.2%
8101.92	-- Bars and rods, other than those obtained simply by sintering, profiles, plates, sheets, strip and foil				
8101.92.10	-- Bars and rods, not alloyed	Free	Free	Free	5.2%
8101.92.20	--- Bars and rods, alloyed; profiles, plates, sheet, strip and foil	10.2%	6.5%	8.1%	5.2%
8101.93	-- Wire				
8101.93.10	--- Not alloyed	Free	Free	Free	5.2%
	--- Alloyed:				
8101.93.21	---- Not coated or covered	8%	5%	6.4%	5.2%
8101.93.22	---- Coated or covered	10.2%	6.5%	8.1%	5.2%
8101.99	-- Other	10.2%	6.5%	8.1%	4.4%

Sources: Customs Tariffs, effective January 1989, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States (First Edition Supplement 2) effective January 1, 1989.

TABLE 1A. CANADA, TUNGSTEN PRODUCTION, CONSUMPTION AND IMPORTS, 1986 AND 1987

	1986		1987	
	(kilograms)	($000)	(kilograms)	($000)
Production[1] (WO_3)	2 469 990	..	-	-
Consumption[2] (W content)				
Tungsten metal and metal powder	632 927	..	740 406	..
Other tungsten products[3]	14 212	..	24 350	..
Total	647 139	..	764 756	..
Imports				
Tungsten in ores and concentrates				
United States	10 000	73	1 000	5
People's Republic of China	1 000	17	-	-
Total	11 000	90	1 000	5
Ferrotungsten[4]				
United States	6 000[r]	115	11 000	151
Total	6 000[r]	115[r]	11 000	151
Tungsten carbide powder				
United States	217 634	5 964	183 660	4 160
Other countries	44 996	1 396	36 015	988
Total	262 630[r]	7 360	219 675	5 148
	(number)	($000)	(number)	($000)
Tungsten carbide rotary rock drill bits				
United States	7 022[r]	31 513	4 810	15 561
Other countries	894[r]	4 333	685	3 061
Total	7 916	35 846	5 495	18 622
Tungsten carbide percussion rock drill bits				
United States	107 513	2 065	180 870	4 043
Ireland	120 406	2 254	24 161	385
West Germany	1 593	48	10 777	310
Other countries	33 543	1 490	35 032	988
Total	263 055	5 857	250 840	5 726
Tungsten carbide tools for metal work				
United States	..	15 768[r]	..	13 427
Other countries	..	6 633[r]	..	6 397
Total	..	22 401[r]	..	19 824

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Producers' shipments. [2] Available data as reported by consumers. [3] Includes tungsten ore, tungsten carbide and tungsten wire. [4] Gross weight.
[r] Revised; - Nil; .. Not available.

TABLE 1B. CANADA, TUNGSTEN PRODUCTION AND TRADE, 1988P

Item No.		1988P	
		(kilograms)	($000)
Production[1] (WO$_3$)		-	-
Imports		(Jan.-Sept.)	
2611.00	Tungsten ores and concentrates		
	United States	205	3
	Total	205	3
2841.80.00	Tungstates (wolframates)		
2841.80.00.90	--- Other		
	United States	6 616	21
	Total	6 616	21
2849.90.00.10	Tungsten carbide		
	United States	411 724	5 674
	France	37 337	603
	West Germany	4 279	56
	Other countries	2 211	37
	Total	455 551	6 370
7202.80.00	Ferro-tungsten and ferro-silico-tungsten		
	United States	65 794	119
	People's Republic of China	17 980	45
	Total	83 775	165
81.01	Tungsten (wolfram) and articles thereof, including waste and scrap		
8101.10	- Powders		
8101.10.10	--- Not alloyed		
	United States	5 603	187
	West Germany	35	...
	Total	5 638	188
8101.10.20	--- Alloyed		
	United States	43 568	1 488
	West Germany	747	30
	Other countries	570	28
	Total	44 885	1 546
	- Other:		
8101.91	-- Unwrought tungsten, including bars and rods obtained simply by sintering; waste and scrap		
8101.91.10	--- Sintered bars and rods, not alloyed		
	United States	3 235	62
	West Germany	95	6
	Total	3 330	68
	---Other:		
8101.91.91	---- Unwrought tungsten, not alloyed		
	United States	192	14
	Total	192	14
8101.91.92	---- Unwrought tungsten, alloyed; waste and scrap		
8101.91.92.10	----- Unwrought tungsten		
	United States	24 539	283
	Total	24 539	283

TABLE 1B. (cont'd)

Item No.		1988P Jan.-Sept.	
		(kilograms)	($000)
Imports (cont'd)			
8101.91.92.20	----- Waste and scrap		
	United States	47 971	303
	Zaire	10 779	161
	United Kingdom	22 163	143
	Total	80 913	607
8101.92	-- Bars and rods, other than those obtained simply by sintering, profiles, plates, sheets, strip and foil		
8101.92.10	--- Bars and rods, not alloyed		
	United States	2 111	205
	United Kingdom	275	24
	Total	2 386	229
8101.92.20	--- Bars and rods, alloyed; profiles, plates, sheets, strip and foil		
8101.92.20.10	----- Not alloyed		
	United States	761	199
	Total	761	199
8101.92.20.20	----- Alloyed		
	United States	7 968	371
	Denmark	1 498	155
	Other countries	683	80
	Total	10 149	606
8101.93	-- Wire		
8101.93.10	--- Not alloyed		
	United States	9 909	1 198
	Total	9 909	1 198
	--- Alloyed:		
8101.93.21	---- Not coated or covered		
	United States	521	142
	Total	521	142
8101.93.22	---- Coated or covered		
	United States	2 450	522
	Japan	192	60
	Total	2 642	582
8101.99.00	-- Other		
	United States	4 277	581
	France	275	38
	Other countries	666	97
	Total	5 218	716
Exports			
2611.00	Tungsten ores and concentrates		
	Sweden	838	40
	Other countries	468	21
	Total	1 306	61

TABLE 1B. (cont'd)

Item No.		1988P Jan.-Sept.	
		(kilograms)	($000)
Exports (cont'd)			
81.01	Tungsten (wolfram) and articles thereof, including waste and scrap		
8101.10	- Powders		
	West Germany	4 553	145
	East Germany	6 000	164
	United States	4 553	145
	Other countries	7 241	319
	Total	22 347	773
8101.91	-- Unwrought tungsten; including bars and rods obtained simply by sintering; waste and scrap		
	United States	7 586	71
	West Germany	97 698	68
	Other countries	202	17
	Total	105 486	156
8101.92	-- Bars and rods, other than those obtained simply by sintering, profiles, plates, sheets, strip and foil		
	Venezuela	219	14
	Australia	148	10
	Other countries	96	9
	Total	463	33
8101.99	-- Other		
	Japan	237	37
	Australia	414	30
	United States	5 433	28
	Other countries	1 094	57
	Total	7 178	152

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Producers' shipments.
P Preliminary; - Nil; ... Amount too small to be expressed.
Totals may not add due to rounding.

TABLE 2. CANADA, TUNGSTEN PRODUCTION, TRADE AND CONSUMPTION, 1975 AND 1980-87

		Imports		
	Production[1]	Tungsten Ore[2]	Ferrotungsten[3]	Consumption[2]
		(kilograms)		
1975	1 477 731	1 000	45 359	451 336
1980	4 007 000	6 000	7 000	290 479
1981	2 515 000	14 000	6 000	401 447
1982	3 029 730	7 620	4 536	485 606
1983	1 537 880	12 000	3 000	503 651
1984	4 195 785	6 000	5 000	659 665
1985	4 030 547	12 000[r]	2 000[r]	707 271
1986	2 469 990	11 000	6 000	647 139
1987	-	1 000	11 000	764 756

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Producers' shipments of scheelite (WO_3 content); [2] W content, available data as reported by consumers; [3] Gross weight.

- Nil; [r] Revised.

TABLE 3. TUNGSTEN ORES AND CONCENTRATES, WORLD MINE PRODUCTION AND CONSUMPTION

Year	Production	Consumption	Imports	Exports
		(metric tons of contained tungsten)		
1979	47 872	51 217	25 689	28 470
1980	50 662	49 149	28 225	30 491
1981	49 222	47 165	27 432	26 389
1982	43 767	40 052	22 844	24 367
1983	41 512	40 020	20 966	25 536
1984	49 313	47 669	26 931	25 813
1985	48 254	45 162	24 924	26 468
1986	43 946	41 949	21 368	23 201
1987	37 886	42 046	21 022	22 511
1988[e]	39 000	44 000	27 000	25 000

Source: Committee on Tungsten, United Nations Conference on Trade and Development (UNCTAD).

[e] Estimated.

Uranium

R.T. WHILLANS

OVERVIEW

The outlook for Canada's uranium industry remained optimistic throughout most of 1988 as The Canada-U.S. Free Trade Agreement (FTA) was moved toward final approval by both national governments. Ratified in late December and implemented on schedule on January 2, 1989, the FTA should stem U.S. attempts to restrict foreign uranium imports for domestic use, and will provide uranium producers in Canada enhanced access to the U.S. market, still the largest in terms of uncommitted demand.

However, uranium spot market prices fell to an all-time low in constant dollar terms, as uncertainty about U.S. restrictions on the importation of uranium and speculation on the outcome of the FTA kept many buyers from a market which had surplus uranium to sell. Despite this uncertainty, which saw the NUEXCO Exchange Value spot-price indicator reach US\$11.75/lb. U_3O_8 at year end, Canadian producers negotiated new sales contracts for some 14 000 tU, double the 1987 level. Annual production again exceeded 12 000 tU, enabling Canada to maintain its position as the world's leading producer and exporter of uranium.

In February 1988, the Canadian and Saskatchewan governments agreed in principle to merge and subsequently privatize Eldorado Nuclear Limited and Saskatchewan Mining Development Corporation (SMDC), their respective Crown companies involved in the uranium business. The merger, effective September 30, 1988, created a large, world-class, integrated uranium mining and processing corporation, headquartered in Saskatoon, Saskatchewan. Known as Cameco - A Canadian Mining & Energy Corporation, the new company employs more than 1 000 persons, has assets of about \$1.6 billion, generates annual sales of some \$500 million, and will rival Compagnie générale des matières nucleaires (COGEMA) of France as the world's foremost fully-integrated uranium producer.

Significant progress was made on three uranium projects in 1988. Cigar Lake Mining Corporation proceeded with its \$40 million test mine at Cigar Lake in northeastern Saskatchewan. At the Midwest Lake project, north of Cigar Lake, Denison Mines Limited announced plans in mid-1988 for an exploratory shaft to test ground conditions and mining methods, and assess the possibility of mid-1990s production. In the Northwest Territories, near Baker Lake, Urangesellschaft Canada Limited began a full-scale mining feasibility study at its Kiggavik project.

Canada should maintain its position as the world's leading producer and exporter of uranium well into the 1990s. With a large share of the world's known uranium resources of economic interest, Canada remains the focus of international uranium exploration activity. The Athabasca Basin in northern Saskatchewan is the principal target for the discovery of very high-grade, low-cost, uranium deposits. In 1988, exploration expenditures in Canada were expected to exceed \$32 million. Ultimately however, the viability of the Canadian uranium industry depends upon global economic growth, the associated demand for energy, the electricity market share obtained by nuclear power, and public acceptance of nuclear power.

PRODUCTION AND DEVELOPMENT

In the 1980s, the decline in uranium prices and the upward pressure on production costs led to reductions in Canada's uranium industry workforce. In January 1988, some 4 800 employees worked at the country's uranium-producing operations, a drop of 20% from the 1984 level. Table 1 summarizes output and employment data for Canada's uranium producers for 1986 and 1987.

In 1988, Canada's five uranium producers reported concentrate output containing 12 400 tU, or about one-third of

---

R.T. Whillans is with the Uranium and Nuclear Energy Branch, Energy, Mines and Resources Canada. Telephone (613) 996-2599.

western world production. The estimates indicate that output increased in Ontario and decreased in Saskatchewan, the reverse of recent years. Figure 1 locates the five existing producers and Canada's major uranium deposits. Based solely on these existing operations, Canada's annual production capability is expected to continue at the 12 000 tU level through the mid-1990s.

Uranium shipments from Canada's five primary producers remain high. As shown in Table 2, the preliminary estimate of shipments made by these producers in 1988 is 13 200 tU, worth over $1.1 billion. The difference between the annual production and shipment figures reflects inventory adjustments by producers. Two-thirds of Canada's uranium output and shipments comes from Saskatchewan, the balance comes from Ontario. As domestic requirements represent 15% of current Canadian output, most of Canada's uranium production is available for export.

To illustrate the importance of uranium as an energy source, Figure 2 compares the thermal energy equivalents of Canada's 1987 production of fossil fuels with that of uranium based on the once-through nuclear fuel cycle. As shown, Canada's uranium output is equivalent, in thermal energy terms, to the production of petroleum and natural gas combined, or almost four times Canada's production of coal. Advanced fuel cycles, such as the reprocessing and recycling of nuclear reactor fuel, can increase greatly the energy produced from each kilogram of uranium mined.

Athabasca Basin, Saskatchewan

At the Rabbit Lake operation, Eldorado Resources Limited (wholly-owned by Eldorado Nuclear, now part of Cameco) received regulatory and environmental approval in January 1988 to proceed with the development of its Collins Bay A and D orebodies, and the Eagle Point deposit. The A and D deposits will each be mined in less than one year by open-pit methods, whereas the Eagle Point orebody will be an underground mine with production potential well into the next century. Late in the year, Uranerz Exploration and Mining Limited acquired Noranda Exploration Company, Limited's one-third interest in the Eagle Point North property; Cameco owns the other two-thirds as well as all of the Eagle Point South property. In 1987, processing of higher-grade ore from the Collins Bay B deposit helped boost output by 80% and in 1988 could raise production again.

Ongoing uranium exploration efforts at Cluff Lake have identified over 4600 tU since 1984, including 3800 tU in 1986, and indicate that the potential for further discoveries is excellent. The Cluff Mining partnership received government approvals in October 1988 to develop its Dominique-Janine open pit prior to ore depletion at the Claude pit in 1989; the Dominique-Peter underground mine and Claude pit provided millfeed in 1988. With production still geared to sales, Cluff Mining operated at up to 1000 t/d ore during 1988, exceeding its 1987 output level. As well, over 250 kg of gold have been recovered since early 1987 from leach residues produced during Phase I of the operation. In February, the last of these residues were reprocessed and the special recovery circuit was decommissioned in May 1988.

Key Lake Mining Corporation (KLMC) continued to decommission the Gaertner pit, now Gaertner Lake, as the larger Deilmann orebody is being prepared for mining in early 1989. Stockpiled ore from Gaertner will feed the Key Lake mill in the interim. A record 26 200 t of ore was processed in April, just prior to a two-month summer shutdown for mill inspections. Throughput was boosted in the last quarter to achieve the 1988 production target of approximately 4600 tU.

Elliot Lake, Ontario

Denison Mines Limited and Rio Algom Limited continue to produce uranium from in-place (underground) leaching to augment primary output. Production from Elliot Lake in 1988 is expected to be slightly higher than in 1987. At its recently acquired Canuc claims, Denison established underground access ahead of schedule, anticipating production in 1989 to supplement output from its adjoining main operation. Rio Algom continued developing its higher-grade Nordic, Lacnor, and Milliken resources, that are tributary to its Stanleigh operation.

Both companies are looking beyond Elliot Lake for their future uranium supply. Rio Algom concluded an agreement with Kerr-McGee Corporation in the United States, for the latter's uranium properties in Wyoming and its shares of wholly-owned Quivira Mining Company; the purchase price is reportedly US$29 million. In September, Rio Algom placed its Lisbon mine in Utah on standby, citing loss of economic reserves due to low uranium prices. Denison is assessing the feasibility of mid-1990s production at its Midwest project in Saskatchewan.

The key 1987 operational characteristics of Canada's existing uranium producers are presented in Table 3.

Additional Production Possibilities

Beyond these existing operations, there are at least three deposits that could be brought on-stream in the 1990s, if warranted by market conditions. In 1988, development work advanced two projects in Saskatchewan and one in the Northwest Territories.

Cigar Lake Mining Corporation, granted an underground exploration permit and environmental approvals in late 1987, proceeded with its $40 million test mine at Cigar Lake in northeastern Saskatchewan. A head-frame is installed, sinking the 490 m deep shaft is well under way and due to be completed by early 1990, and underground test stoping in 1990 will permit final feasibility studies in 1990/91. Given a successful underground program and requisite government approvals, construction of a mill could begin in 1992, with production at a rate of 4600 tU/y commencing in 1993. The Cigar Lake deposit, the world's largest and richest, has known geologic resources that total 150 000 tU in ore grading 10% U.

At the Midwest Lake project, north of Cigar Lake, Denison Mines Limited started work on an exploratory shaft, the first step in an $18 million, three-year program to test ground conditions and mining methods. Given provincial environmental approval in September, the 185 m deep shaft was collared, and site preparations, including the head-frame, were essentially completed by year-end 1988. Denison and its partners, PNC Exploration (Canada) Co. Ltd., Uranerz Exploration and Mining Limited, and Bow Valley Industries Ltd. are assessing the possibility of mid-1990s output from drill-indicated resources reported to exceed 20 000 tU in ore grading 1% U.

In the Northwest Territories, near Baker Lake, Urangesellschaft Canada Limited proceeded with a full-scale mining feasibility study for its $200 million Kiggavik project. The decision to proceed will depend on final reserve estimates, the uranium market, and the search for partners. In late 1988, CEGB Exploration (Canada) Ltd. acquired a 20% interest in the project. Output of about 1500 tU/y could be expected, perhaps during the mid-1990s, from resources reported to exceed 15 000 tU in ore grading 0.4% U.

EXPLORATION

In 1988, EMR's Uranium Resource Appraisal Group (URAG) completed its fourteenth annual uranium supply assessment and survey of exploration activity. The results were reported[1] late in 1988. Table 4 summarizes uranium exploration activity in Canada from 1976 to 1987, showing that efforts are back to the level of a decade ago, having risen sharply in the interim. Interestingly, the number of "million-dollar" projects has stayed relatively constant over the period 1982 to 1987.

In 1987, uranium exploration expenditures in Canada rose modestly to $37 million, and exploration drilling actually increased, even though activity was focussed mainly on properties with proven resources. This increase is significant in light of the continued decline in spot market price indicators, which have historically influenced exploration levels. Grass-roots exploration efforts in new areas in eastern Canada and the Northwest Territories continue to show promise. Exploration efforts in 1988 were again concentrated in the Athabasca Basin of northern Saskatchewan, as will most likely be the case for the immediate future. Continued successes there have added significantly to Canada's uranium resource base throughout the 1980s.

Uranium discoveries in Canada have replaced actual production of about 35 000 tU since 1984 and, in addition, have compensated for the reassignment to higher price categories of some resources that are no longer of economic interest.

The 10 most active operators[2] in 1987 spent 97% of the $37 million total expenditure. In alphabetical order they were: Amok Ltd., CEGB Exploration (Canada) Ltd., Cigar Lake Mining Corporation, Cogema Canada Limited, Eldor Resources Limited, Minatco Ltd., PNC Exploration

---

[1] "Canadian Production and Exports of Uranium Reach Record Levels" - News Release 88/215, EMR Canada, September 23, 1988.

[2] In certain cases, the identified operator has reported the total expenditures of a joint-venture effort. Therefore, contributions by other parties not responding to the URAG survey are accounted for in the $37 million total.

(Canada) Co. Ltd., Saskatchewan Mining Development Corporation, Uranerz Exploration and Mining Limited, and Urangesellschaft Canada Limited.

As shown in Figure 3, foreign-based companies committed about two-thirds of the total expenditures in Canada, the bulk of this being spent by non-U.S. firms. This reflects the sizeable stake most of Canada's major uranium customers are willing to commit to the future of the Canadian uranium industry, in their quest for reliable sources of supply for their nuclear power programs. By comparison, expenditures by U.S. companies have declined from 28% to 3% of total Canadian expenditures from 1981 to 1987. However, changes in Canada's foreign ownership policy, discussed below, and the Free Trade Agreement could reverse this trend.

The most recent edition of "Uranium: Resources, Production and Demand", the joint Nuclear Energy Agency (NEA) and International Atomic Energy Agency (IAEA) assessment of world uranium supply, published in March 1988 and better known as the "Red Book", indicates that the Canadian and Australian share of total western world uranium exploration expenditures has remained constant since 1981, as shown in Table 5. While expenditures declined in the United States, and the U.S. share dropped by half, expenditures in France have remained high, and in 1986 accounted for over 40% of the western world total, illustrating the commitment to nuclear power in that country, and its desire to find indigenous supplies of uranium.

GOVERNMENT INITIATIVES

New Foreign Ownership Policy

In December 1987, Canada's new policy on non-resident ownership in the uranium mining sector was announced. Its primary objective is a 51% level of Canadian equity in an individual uranium property when production begins. However, lower levels of Canadian ownership would be permitted if Canadian control can be clearly demonstrated. Only in cases where Canadian partners cannot be found would exemptions to the policy be considered, and these would require Cabinet approval.

Designed to encourage investment in Canada's uranium mining industry, and to promote economic development, exports and jobs for Canadians, the new policy will provide considerably more flexibility to investors, both Canadian and foreign, than did the previous policy, and should significantly facilitate the efforts of those interested in financing the development of recent Canadian uranium discoveries.

Eldorado/SMDC Merger

In February 1988, the Canadian and Saskatchewan governments agreed to merge and privatize Eldorado Nuclear Limited and Saskatchewan Mining Development Corporation, their respective Crown companies involved in the uranium business. The merger created Cameco, a large, world-class, integrated uranium mining and processing corporation, headquartered in Saskatoon, Saskatchewan. Initially, the Canadian government will own 38.5% of Cameco and the Saskatchewan government 61.5%. These shareholdings will be reduced through privatization by 30% within two years, 60% within four years, and 100% within seven years.

As an objective of the privatization initiative is to distribute equity widely amongst Canadians, no individual Canadian shareholder will be entitled to more than 25% of voting rights and no individual non-Canadian shareholder will be entitled to more than 5%. Non-Canadian shareholders in the aggregate will be restricted to 20% of votes cast at a meeting of shareholders.

In December, Cameco announced that a $650 million loan had been negotiated with eleven Canadian, European and Japanese banks. As the founding shareholders, the Saskatchewan and Canadian governments will receive the proceeds of this debt issue, in proportion to their holdings; their remaining proceeds will be realized through the gradual sale of their equity in Cameco, as it is privatized.

Cameco owns two thirds of the Key Lake operation, 100% of the Rabbit Lake/Collins Bay production centre, and 20% of the Cluff Mining partnership. It will be a strong competitor in the international uranium market, with control of 15% of current western world production, and will rival COGEMA of France as the world's foremost fully-integrated uranium producer. Interestingly, Cameco and COGEMA are partners in the Cigar Lake project, holding 48.75 and 36.375%, respectively.

Cameco will be well placed to provide for the needs of the established customers of Eldorado and SMDC. The company will control 40% of Canada's known uranium resources of economic interest, ensuring its long-term supply capability. It will also control Eldorado's established uranium refining and conversion plants in Ontario, the services of which will continue to be available on a competitive basis for the processing of both Canadian and non-Canadian uranium.

Canada-U.S. Free Trade Agreement (FTA)

On January 2, 1988, the Canadian and U.S. governments signed a very wide-ranging bilateral Free Trade Agreement providing for the elimination of barriers to trade in goods and services between the two countries. Implementing legislation was approved quickly by the U.S. House of Representatives (August 9), by Canada's House of Commons (August 31), and by the U.S Senate (September 19), but was delayed by the Canadian Senate, forcing a federal election. The November 21, 1988, majority win by the Conservatives permitted the enactment of the necessary legislation in Canada by year-end, providing for implementation of the agreement on January 2, 1989, as scheduled.

Chapter Nine of the Agreement, dealing with Energy, contains two uranium-specific provisions. The United States has agreed to "exempt Canada from any restriction on the enrichment of foreign uranium under Section 161v of the Atomic Energy Act," and Canada has agreed to "exempt the United States of America from the Canadian Uranium Upgrading Policy as announced by the Minister of State for Mines on October 18, 1985." In addition, Chapter Sixteen of the FTA, which deals with Investment, provides for the "grandfathering" of published policies with respect to foreign investment in the oil and gas, and uranium mining industries.

Clearly, the FTA is very important to the future of Canada's uranium industry. The United States is currently Canada's largest customer for uranium, averaging over one-third of Canada's exports, valued at some $300 million annually. Canadian uranium producers supplied more than 40% of U.S. domestic requirements in 1987 and are the largest single source of uranium for U.S. utilities.

The FTA provides clear benefits to both Canada and the United States. For Canada, the FTA ensures that Canadian producers will not be affected by any enrichment restrictions that may be imposed under the U.S. Atomic Energy Act or by any import restrictions that may be imposed by new legislation. For the United States, provisions in the FTA's Energy Chapter ensure that U.S. utilities will have access to Canadian uranium on competitive terms.

On December 30, 1988, the Minister of Energy, Mines and Resources Canada informed Canada's uranium industry by letter how the FTA phrase "exempt the United States of America from the Canadian uranium upgrading policy" will be applied in the approval of uranium export contracts. "Canada will, on request from a Canadian vendor, grant an exemption from the further processing policy for a particular export contract in cases where: the Canadian uranium will be refined and converted in the United States and will be actually consumed in a reactor in the United States; or the Canadian uranium will be refined, converted and enriched in the United States prior to export to a third country." These two provisions cover the refining and conversion of some 70% of Canada's uranium exports.

United States Import Restrictions

On June 15, 1988, in a development relevant to Free Trade, the United States Supreme Court ruled that U.S. law does not require the U.S. Department of Energy (DOE) to restrict the enrichment of foreign uranium "unless it is assured such action would maintain a viable domestic uranium industry." This decision reversed earlier lower court rulings, and remanded the case back to the U.S. Tenth Circuit Court in Denver, for further deliberation. A ruling in favour of the plaintiffs, the Uranium Producers of America, would have compelled DOE to cease enrichment of foreign uranium destined for domestic consumption, regardless of the impact of such restrictions on the viability of the domestic uranium industry.

In early January 1989, the U.S. Secretary of Energy determined that the U.S. uranium mining and milling industry was not viable again in 1987. Furthermore, foreign imports of uranium in 1986 and 1987 reached 44 and 51%, respectively, of U.S. annual demand. As required by legislation, since uranium imports exceeded 37.5% for two consecutive years, the Secretary of Energy has requested the Secretary of Commerce to initiate an investigation, under Section 232 of the Trade Expansion Act of 1962, to determine the effects of these imports on national security.

New Uranium and Thorium Mining Regulations

Pursuant to Canada's Atomic Energy Control Act, new Uranium and Thorium Mining Regulations were approved by the Governor-in-Council on April 21, 1988. Establishing firmly in law what had previously been applied mainly through licence conditions, the new regulations reflect the Canadian government's commitment to the health and safety of workers, and protection of the environment. They do not impose significant new obligations on mine operators and, with certain exceptions, simply formalize what has become standard practice.

RESOURCES

Uranium exploration successes in Canada since 1984 have resulted in significant additions to known uranium resources of current economic interest. For reference, Figure 1 shows the location of the principal uranium deposits in Canada, containing the bulk of the known uranium resources. From 1984 to the end of 1987, new uranium discoveries have replaced production of some 35 000 tU and have compensated for the reassignment to higher price categories of some resources that are no longer of economic interest.

The 1987 URAG assessment of Canadian uranium resources, which reflect these continued exploration and development successes, reports that known uranium resources recoverable from mineable ore at the end of 1987 were an estimated 559 000 tU, up from the 551 000 tU reported for 1984. The total represents resources that could be recovered from mined ore at a price of $300/kgU or less; some 258 000 tU are in the so-called low-cost category, i.e., recoverable at a price of $100/kgU or less.

The estimates of recoverable uranium resources for 1987 are shown in Table 6 with the 1986 results[1]. The slight decline in known uranium resources from 1986 to 1987 reflects record production, which just exceeded the amount added to resources as a result of the ongoing delineation of recently discovered uranium deposits in northern Saskatchewan. Such activities generally shift resources from the less well-defined categories to the better-defined categories.

Figure 4 places Canada in the world context in terms of Reasonably Assured Resources of uranium, recoverable from mineable ore at a cost of US$130/kgU or less. As shown, Canada continues to have a significant share of the western world's known resources of economic interest, along with Australia, South Africa and the United States.

It is interesting to note that over the past few years, there has been a gradual geographical redistribution of Canada's known uranium resources that are of economic interest. The shift in exploration activity to northern Saskatchewan led to new discoveries that caused the major redistribution; however, rising costs and downward pressure on prices have eliminated some resources from the national inventory, accentuating this "east-to-west" trend. In 1980, about 31% of the known uranium resources were in Saskatchewan and 63% were in Ontario; the 1987 distribution of resources is nearly reversed at 52% and 42%, respectively.

SUPPLY CAPABILITY

Annual production capability from Canada's existing operations is expected to remain at about 12 000 tU until the mid-1990s, but higher prices will be required to sustain current production levels at some of these projects. To illustrate uranium availability in the short term, Figure 5 provides two projections of production capability. The upper curve assumes a level of production that can be realistically expected, supported by known resources recoverable at prices of $150/kgU or less. The lower curve is based only on resources in the so-called low-cost category. No commitments have been made for the start-up of any production centres beyond those currently in operation.

Compared to its uranium production capability, Canada's uranium requirements remain modest, at about 15% of actual output. The 85% proportion that is available for export has varied little over time, as growth in uranium production capability in Canada has kept pace with expansions in installed nuclear generating capacity. Future developments will clearly be dependent on the evolution of the market. Given adequate uranium prices, reasonably secure world demand, and continued access to major markets, Canada could increase its level of production beyond that currently projected from existing operations, perhaps to an annual output of 15 000 tU or more.

---

[1] "Uranium in Canada: 1986 Assessment of Supply and Requirements," Report EP 87-3, EMR Canada, September 1987.

MARKETS AND PRICES

Canada has maintained its position as the world's leading producer of uranium, as shown in Table 7. Despite continued market uncertainty in 1988, Canadian producers negotiated new sales contracts for some 14 000 tU, double the 1987 level. Table 8 indicates the total amount of uranium under Canadian export contracts approved since 1974, and illustrates the diversity of Canada's export customers. As of January 1989, forward commitments under the 50-odd export contracts and the handful of domestic contracts exceeded 60 000 tU and 70 000 tU, respectively.

While the average price of Canadian export deliveries held fairly steady at about $90/kgU from 1984 to 1986, it declined to $79/kgU in 1987 largely because the proportion of deliveries attributable to spot sales increased again, from 21% in 1986 to 35% in 1987. Although prices under both spot and long-term export contracts declined by roughly 10% in 1988, the average price of the combined deliveries held at $79/kgU, due mainly to a drop in spot sales volume to 13% of total 1988 export deliveries. The average price of Canadian export deliveries from 1974 to 1988 is shown in Table 9.

Uranium spot market prices remained significantly lower compared to Canada's average export price, which in U.S. dollar terms was US$25/lb. U_3O_8; the NUEXCO monthly Exchange Value[1] fell from US$16.30 in January to US$11.75/lb. U_3O_8 at year end.

Actual exports in 1988 are expected to be well below the record level of 1987. Table 10 summarizes exports of Canadian origin uranium from 1983 to 1987 for each of Canada's principal export customers. Tables 11 and 12 tabulate the value of Canadian exports of Radioactive Ores and Concentrates and Radioactive Elements and Isotopes reported by Statistics Canada. Figure 6 shows the future importance of Canada's export markets in terms of forward scheduled deliveries of uranium in concentrates.

REFINING

Cameco operates the only uranium refining and conversion facilities in Canada, (formerly owned by Eldorado Resources Limited), located at Blind River and Port Hope, Ontario, respectively. Mine concentrates containing some 10 900 tU were processed in 1987, one-third more than the previous production record set in 1986, and unit processing costs were reduced by 14%. In 1987, substantial cost reductions were achieved at the Blind River refinery where production of uranium trioxide (UO_3), an intermediate product, was increased.

The Port Hope conversion operation produced record volumes of both uranium hexafluoride (UF_6) and uranium dioxide (UO_2) in 1987. The installation of additional equipment in the new UF_6 plant contributed to the higher output levels.

NUCLEAR POWER DEVELOPMENTS

According to the NEA's 1988 "Red Book" Statistical Update, installed nuclear generating capacity in WOCA[1] exceeded 267 000 megawatts electric (MWe) in 1988, and was expected to reach an estimated 306 900 MWe by 1995, and 353 000 MWe by 2005. Estimates of the reactor-related uranium requirements for this installed capacity were 38 620 tU, 46 290 tU, and 55 185 tU for 1988, 1995, and 2005, respectively.

At the end of 1988, 18 CANDU reactors with a total generating capacity of some 12 000 MWe were in service in Canada, as shown in Table 13; four additional reactors under construction in 1988 will enter service between 1989 and 1992, adding 3 500 MWe to the Ontario Hydro grid. In 1988, about 16% of Canada's electric power was nuclear-generated, while in Ontario it was a half, and in New Brunswick about a third.

---

[1] The price at which transactions for significant quantities of natural uranium concentrates could be concluded as of the last day of the month according to Nuclear Exchange Corporation (NUEXCO), a Colorado-based uranium brokerage firm.

[1] World Outside Centrally-Planned Economy Areas.

CANDU reactors continue to maintain their standing among the world's best performers. In mid-1988, seven CANDUs in Canada were in the top ten in terms of lifetime operation, out of some 260 commercial power reactors of 500 MWe size or greater in service worldwide.

East of Toronto, Ontario Hydro's Pickering Unit 2 was recommissioned in November 1988, a year after Unit 1 was recommissioned, following the retubing of both reactor vessels; Ontario Hydro's Darlington Unit 2 is being commissioned and could enter service in mid-1989.

Discussions continued with The New Brunswick Electric Power Commission on the building of a 450 MWe CANDU 3, adjacent to the existing Point Lepreau reactor. In Saskatchewan, a private consortium has proposed building a CANDU 3 and selling the electricity generated to the provincial utility, Saskatchewan Power Corporation (SPC).

OUTLOOK

The future ability of Canada's uranium industry to supply its established markets was enhanced in 1988. A new policy on non-resident ownership, introduced late in December 1987, is aimed at providing considerably more flexibility for investors interested in developing Canada's uranium potential. Cameco, a world-class uranium company, was created, and is well placed to continue to serve both its existing and potential new customers. The Free Trade Agreement removes the threat of barriers to uranium trade between Canada and the United States, enabling the industries in both countries to develop in an orderly, free-market environment.

In addition, an emerging awareness of the advantages of nuclear power bodes well for its future. Canada's Parliamentary Standing Committee on Energy, Mines and Resources released a report in August 1988 entitled "Nuclear Energy - Unmasking the Mystery." In its report the Committee stated its position very clearly.

> "Maintaining the nuclear power option is vital to Canada's interests, as it is vital to the interests of society in general. There is a compelling case to be made in support of continued nuclear development, a case based upon the future inadequacy of conventional petroleum resources and upon the environmental degradation arising from burning coal in progressively greater quantities for electricity generation."

Interestingly, a November 1988 poll by Decima Research showed that eight out of ten Canadians feel that nuclear energy is a good or realistic choice for large-scale generation of electricity and that it will be an important future source of energy. The poll also revealed that six out of ten Canadians currently favour nuclear energy as one of the ways to generate electricity.

In the long term however, the viability of the Canadian uranium industry depends upon several factors, both in Canada and abroad: economic growth, the associated demand for energy, the electricity market share obtained by nuclear power, and public perception.

TABLE 1. URANIUM PRODUCTION IN CANADA AND WORK FORCE SUMMARY, 1986 AND 1987

Province and Producer	Total Work Force (Dec. 31) 1986	Total Work Force (Dec. 31) 1987[1]	Annual Output 1986	Annual Output 1987
			(tU)	
Athabasca Basin, Saskatchewan:				
Key Lake Mining Corporation	425	400	4 834	5 199
Eldorado Resources Limited	376	370	1 227	2 193
Cluff Mining	220	200	834	829
Sub-total	1 021	970	6 895	8 221
Elliot Lake, Ontario:				
Denison Mines Limited	1 737	1 670	2 015	1 809
Rio Algom Limited				
- Quirke	1 132	1 080	1 259	1 108
- Panel	653	620	886	826
- Stanleigh	537	490	668	471
Sub-total	4 059	3 860	4 828	4 214
Total	5 080	4 830	11 723	12 435[r]

Sources: Company annual reports; Atomic Energy Control Board open files.

[1] Figures rounded.

[r] Revised.

TABLE 2. VALUE OF URANIUM SHIPMENTS[1] BY PROVINCE, 1985-88

	1985	1986	1987	1988[P]
Ontario producer shipments (tU)	4 499	4 752	4 901	4 543
Value of shipments ($ million)	553	566	581	523
Saskatchewan producer shipments (tU)	5 942	6 750	8 711	8 690
Value of shipments ($ million)	450	476	601	585
Total producer shipments (tU)	10 441	11 502	13 612	13 233
Total value of shipments ($ million)	1 002	1 042	1 182	1 108

[1] Shipments in tonnes of uranium (tU), contained in concentrate, from ore processing plants.

[P] Preliminary.

TABLE 3. OPERATIONAL CHARACTERISTICS OF EXISTING CANADIAN URANIUM PRODUCTION CENTRES, 1987

	Ore-processing Plant[1]			
	Capacity		Annual Throughput	
Company/Facility Name	Nameplate/ Actual	Recovery Overall	Ore Total	Ore Grade
	(t/d)	(%)	(t)	(% U)
Cluff Mining/Cluff Lake	> 800/ 700	96	206 000	0.42
Denison Mines Limited/Elliot Lake	13 600/7 600	95	2 350 000	0.08
Eldorado Resources Limited/Rabbit Lake	1 800/1 900	94	451 600	0.51
Key Lake Mining Corporation/Key Lake	700/ > 700	98	282 400	1.87
Rio Algom Limited/Elliot Lake				
- Quirke	5 000/4 700	95	1 496 000	0.08
- Panel	3 000/2 900	95	917 000	0.09
- Stanleigh	4 500/3 300	95	718 000	0.07

Sources: Corporate annual reports and the Atomic Energy Control Board (AECB).
[1] Figures rounded.

TABLE 4. URANIUM EXPLORATION ACTIVITY IN CANADA, 1976-87

Year	Expenditures[1]	Drilling[2]	Million-Dollar Projects[3]
	($ million)	(km)	
1976	44	155	4
1978	90	334	7
1980	128	503	24
1982	71	247	13
1984	35	197	12
1986	33	162	11
1987	37	164	12

[1] Direct exploration and drilling expenditures in current dollars. [2] Exploration and surface development drilling; excludes development on producing properties. [3] Number of projects where direct exploration and drilling expenditures exceeded $1 million in current dollars.

TABLE 5. URANIUM EXPLORATION EXPENDITURE TRENDS IN MAJOR TARGET COUNTRIES IN WOCA[1]

	1981	1986
	(percentage of WOCA Expenditure)	
Canada	16	17
United States	34	17
France	13	43
Australia	8	8
Other	29	15
Total $US (million)	537	150

Source: NEA/IAEA 1988.
[1] World Outside Centrally-Planned Economy Areas.

TABLE 6. ESTIMATES[1] OF CANADA'S URANIUM RESOURCES RECOVERABLE FROM MINEABLE ORE[2], 1986 AND 1987

Price Ranges Within Which Mineable Ore is Assessed[3]	Measured		Indicated		Inferred	
	1986	1987	1986	1987	1986	1987
			(000 tonnes U)			
A	46	44	107	104	112	110
B	1	1	95	94	99	98
A + B	47	45	202	198	211	208
C	23	23	33	33	51	52
A + B + C	70	68	235	231	262	260

[1] Interim revisions for 1987; comprehensive assessment for selected properties only. [2] Actual or expected losses in mining recovery and ore processing have been accounted for; these factors were individually applied to resources tributary to existing or prospective production centres. In underground operations, mineable ore is generally 75 to 85% of the ore-in-place; higher mining recoveries are achievable in open-pit operations. Ore-processing recoveries in Canada normally range from 90 to 97%; Canada's weighted average mill recovery for existing conventional uranium operations was 96% in 1987. [3] The price ranges are (A) $100/kgU or less, (B) between $100 and $150/kgU and (C) between $150 and $300/kgU. The Canadian dollar figures reflect the price of a quantity of uranium concentrate containing 1 kg of elemental uranium. The prices were used in determining the cut-off grade at each deposit assessed, taking into account the mining method used and the processing losses expected. The price of $100/kgU was used by URAG to illustrate those resources that were of economic interest to Canada in 1986 and 1987.
Note: $1/lb. U_3O_8 = $2.6/kgU.

TABLE 7. PRODUCTION OF URANIUM IN CONCENTRATES BY MAJOR PRODUCING COUNTRIES, 1982-87

	1982	1983	1984	1985	1986	1987
			(tonnes U)			
Canada	8 080	7 140	11 170	10 880	11 720	12 440
United States	10 330	8 140	5 720	4 350	5 200	5 000
South Africa	5 820	6 060	5 740	4 880	4 610	3 960
Namibia	3 780	3 720	3 690	3 600	3 300	3 540
Australia	4 420	3 210	4 390	3 250	4 150	3 780
Niger	4 260	3 470	3 400	3 180	3 110	3 000
France	2 860	3 270	3 170	3 200	3 250	3 380
Gabon	970	1 040	1 000	940	900	800
Other[1]	970	900	950	900	870	890
Total[2]	41 490	36 950	39 230	35 180	37 110	36 790

Sources: "Uranium: Resources, Production and Demand," a report jointly produced by the Nuclear Energy Agency of the OECD and the International Atomic Energy Agency, and miscellaneous national and international reports. Country figures are rounded to the nearest 10 tU.
[1] Includes Argentina, Belgium, Brazil, Federal Republic of Germany, India, Israel, Japan, Portugal, Spain and Yugoslavia (1984). [2] Totals are of the listed figures only.

TABLE 8. CANADIAN URANIUM UNDER EXPORT CONTRACT[1]

Country of Buyer[2]	Tonnes U
Belgium	3 325
Finland	3 512
France	9 715
Italy	1 115
Japan	25 046
South Korea	6 903
Spain	3 559
Sweden	8 977
Switzerland	154
United Kingdom	8 293
United States	57 718
West Germany	15 126
Total	143 443

[1] The quantity of uranium specified in all contracts reviewed and accepted under Canadian uranium export policy since September 5, 1974. Country totals are adjusted to reflect new and amended contracts as of December 31, 1988. [2] In most cases, indicates country of end-user.

TABLE 9. CANADIAN URANIUM EXPORT PRICE[1], 1974-88

	Average Export Prices		Spot Sale
Year	Current Dollars	Constant 1988 Dollars	Portion of Deliveries
	($/kgU)		(%)
1974	39	96	nr
1975	52	116	nr
1976	104	213	nr
1977	110	212	nr
1978	125	227	nr
1979	130	215	nr
1980	135	202	nr
1981	110	149	1.0
1982	113	140	1.5
1983	98	116	10
1984	90	103	26
1985	91	101	20
1986	89	97	21
1987	79	82	35
1988	79	79	13

[1] EMR's Uranium Resource Appraisal Group (URAG) derives the Export Price figure annually. It is based on the average price under all export contracts made by Canadian producers for deliveries in the given year; prices are rounded.
Note: The constant dollar values are derived using the Implicit Price Index for Gross Domestic Product.
nr Not reported.

TABLE 10. EXPORTS OF URANIUM OF CANADIAN ORIGIN, 1983-87

Country of Final Destination	1983	1984	1985	1986	1987
	(tonnes of contained uranium[1])				
Belgium	-	121	157	63	-
Finland	179	137	81r	116	142
France	435	525	612r	1 013r	1 438
Italy	-	50	53	301	293
Japan	663	2 436	1 799	816	1 317
Netherlands	-	-	-	85r	40
South Korea	94	30	194	402r	828
Spain	-	-	-	150	150
Sweden	613	254	514	449	377
Turkey	-	-	-	2	-
United Kingdom	675	692	685r	700	824
United States	860	2 397	3 524r	3 692r	6 063
West Germany	490	295	269	654	1 317
Total	4 009	6 937	7 888r	8 443r	12 789

Source: Atomic Energy Control Board.
[1] Some of this uranium was first exported to an intermediate country, for conversion and/or enrichment, prior to transfer to the country of final destination.
r Revised to reflect adjusted figures for the country of final destination (see [1] above); - Nil.

TABLE 11. VALUE OF EXPORTS[1] OF RADIOACTIVE ORES AND CONCENTRATES[2] FROM CANADA, 1982-87

Country of Initial Destination	1982	1983	1984	1985	1986	1987
			($000)			
United States[3]	346 891	25 400	295 686	98 086	127 418	226 596
United Kingdom	11 690	37 175	28 188	113 753	19 893	25 812
Japan	-	-	3 475	15 514	-	-
West Germany	-	-	6 149	1 823	-	-
France	-	-	36	4 418	19 054	23 943
South Korea	-	-	-	-	461	893
Netherlands	-	-	167	-	-	798
Other	-	-	2	-	-	8
Total	358 581	62 575	333 703	233 594	166 826	278 050

Source: Statistics Canada.
[1] Material clearing customs with destinations as indicated. [2] Primarily uranium in concentrates, i.e., yellowcake. [3] Includes sales to the United States, as well as material destined for transshipment, primarily to western Europe and Japan, following conversion and enrichment in the United States.
- Nil.

TABLE 12. VALUE OF EXPORTS[1] OF RADIOACTIVE ELEMENTS[2] AND ISOTOPES FROM CANADA, 1982-87

Country of Initial Destination	1982	1983	1984	1985	1986	1987
			($000)			
United States[3]	299 246	261 168	416 670	434 183	437 709	351 197
France	36 213	39 037	28 988	77 492	144 629	135 796
United Kingdom	796	2 303	1 601	22 174	6 056	26 935
Japan	19 617	12 371	35 729	35 892	6 624	12 119
West Germany	37 250	32 208	14 364	3 892	29 561	41 254
Italy	325	193	527	4 908	13 324	3 998
U.S.S.R.[4]	34 854	8 148	-	-	-	-
Netherlands	45	1 517	598	702	18 136	8 590
Finland	199	11	20 128	5 437	7 095	7 938
Argentina	214	315	520	1 305	1 136	1 163
South Korea	123	3 057	8 311	150	310	7 777
Other	5 151	7 287	13 256	4 943	10 024	11 477
Total	434 033	367 615	540 700	591 078	674 604	608 244

Source: Statistics Canada.
[1] Material clearing customs with destinations as indicated. [2] Includes uranium hexafluoride (UF_6) and radioisotopes for medical and industrial purposes. [3] UF_6 component includes sales to the United States, as well as material destined for transshipment, primarily to western Europe and Japan, following enrichment. [4] UF_6 component destined entirely for transshipment to western Europe, following enrichment.
- Nil.

TABLE 13. NUCLEAR POWER PLANTS IN CANADA[1]

Reactors	Owner	Net Capacity (MWe)	In-service Dates
Pickering 1 to 4	Ontario Hydro	2 060	1971-73
Bruce 1 to 4	Ontario Hydro	3 066	1977-79
Point Lepreau	New Brunswick Electric Power Commission	635	1983
Gentilly 2	Hydro-Québec	638	1983
Pickering 5 to 8	Ontario Hydro	2 064	1983-86
Bruce 5 to 8	Ontario Hydro	3 394[r]	1984-87
Darlington 1 to 4	Ontario Hydro	3 524	1989-92[e]
Total net capacity expected by 1993		15 381	

[1] As of December 1988.
[r] Revised; [e] Expected.

Figure 1

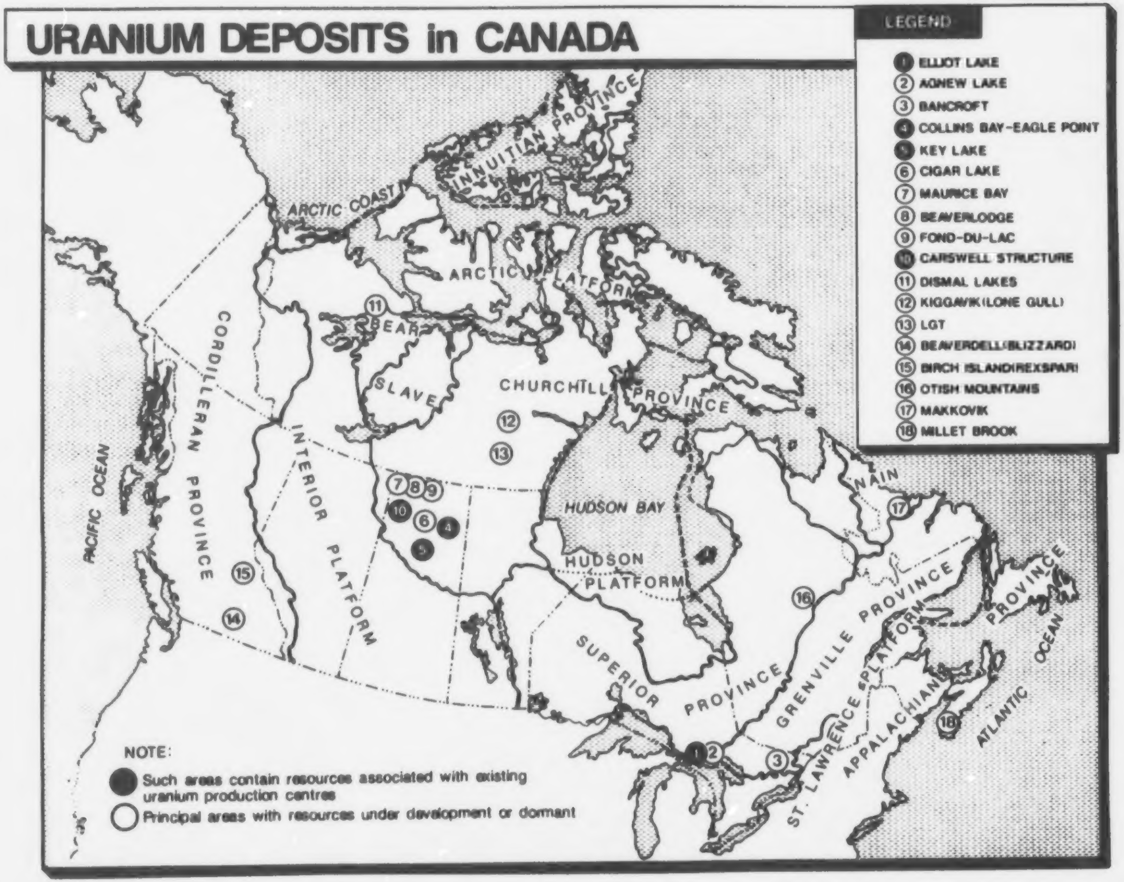
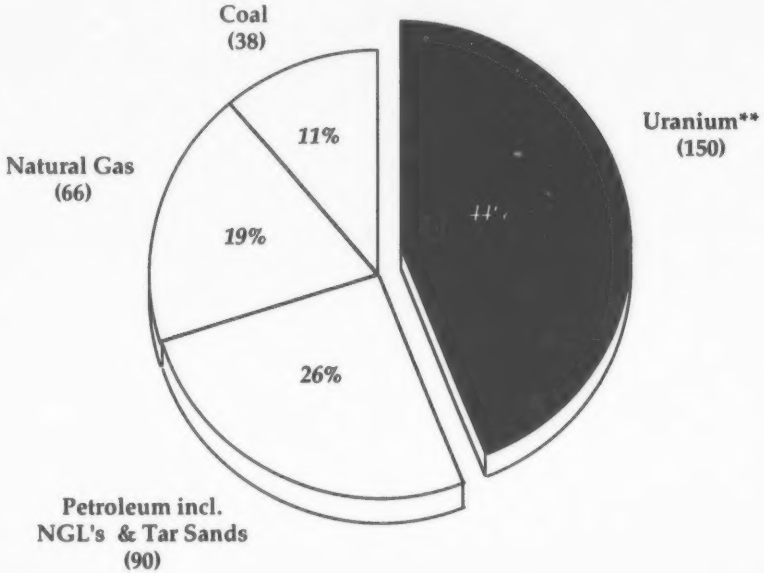

URANIUM DEPOSITS in CANADA
LEGEND
① ELLIOT LAKE
② AGNEW LAKE
③ BANCROFT
④ COLLINS BAY-EAGLE POINT
⑤ KEY LAKE
⑥ CIGAR LAKE
⑦ MAURICE BAY
⑧ BEAVERLODGE
⑨ FOND-DU-LAC
⑩ CARSWELL STRUCTURE
⑪ DISMAL LAKES
⑫ KIGGAVIK (LONE GULL)
⑬ LGT
⑭ BEAVERDELL (BLIZZARD)
⑮ BIRCH ISLAND (REXSPAR)
⑯ OTISH MOUNTAINS
⑰ MAKKOVIK
⑱ MILLET BROOK
INNUITIAN PROVINCE
ARCTIC COAST
ARCTIC PLATFORM
BEAR
SLAVE
CHURCHILL PROVINCE
CORDILLERAN PROVINCE
INTERIOR PLATFORM
PACIFIC OCEAN
HUDSON BAY
HUDSON PLATFORM
NAIN
SUPERIOR PROVINCE
GRENVILLE PROVINCE
ST. LAWRENCE PLATFORM
APPALACHIAN PROVINCE
ATLANTIC OCEAN
NOTE:
● Such areas contain resources associated with existing uranium production centres
○ Principal areas with resources under development or dormant

Figure 2

CANADIAN PRODUCTION OF MINERAL FUELS IN 1987 (MTOE)*



**Thermal Energy Equivalents, Measured in Million of Tonnes of Oil Equivalent i.e. MTOE*

***Used in a "Once-Through" Nuclear Fuel Cycle*

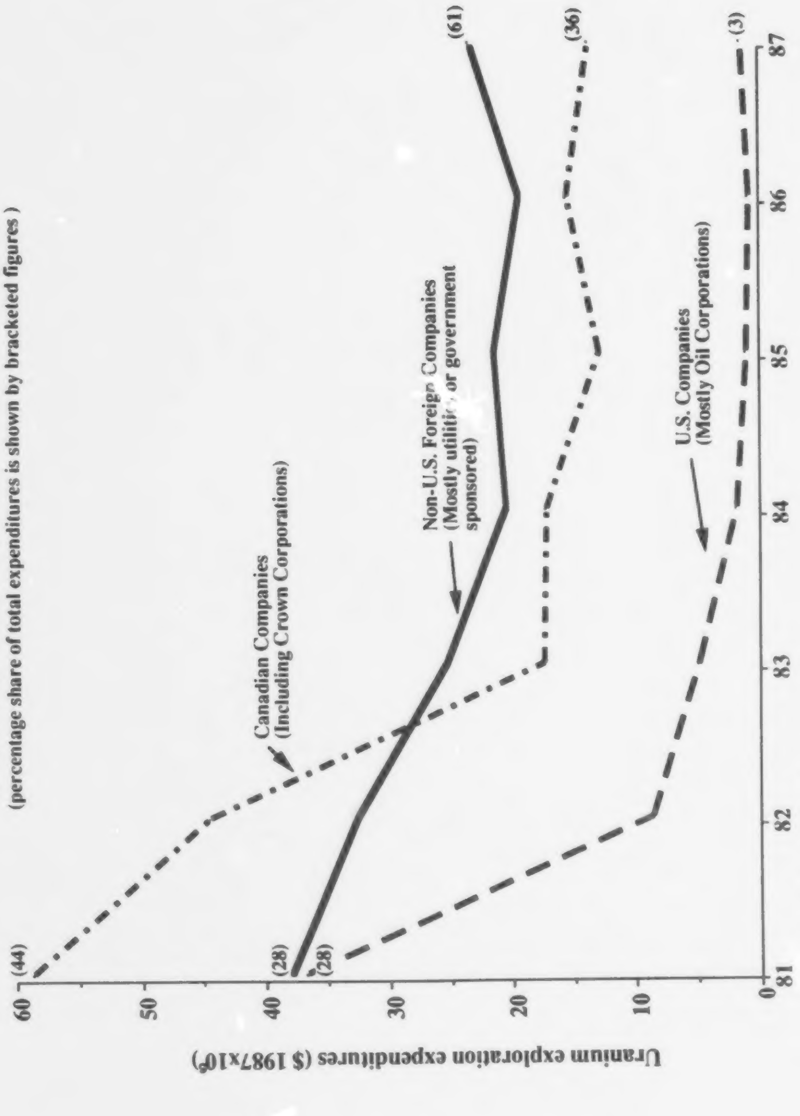
Source: EMR/UNEB

1 MTOE is Equivalent to:
84 tonnes Uranium
7.58 million barrels Oil
1.111 billion cu.m. Natural Gas
1.5 million tonnes Hard Coal
3.0 million tonnes Soft Coal
42 Petajoules

Figure 3

TREND IN URANIUM EXPLORATION EXPENDITURES IN CANADA

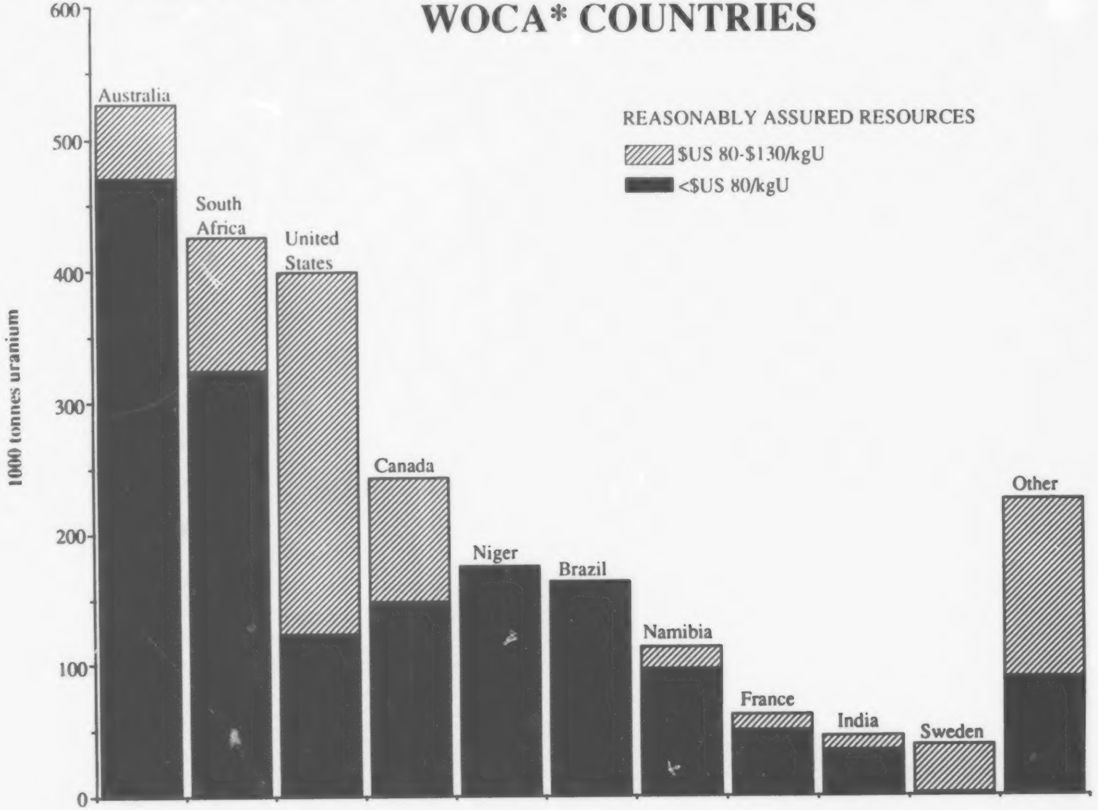
(percentage share of total expenditures is shown by bracketed figures)



Source: EMR Canada 1988

Figure 4

DISTRIBUTION OF URANIUM RESOURCES AMONG WOCA* COUNTRIES

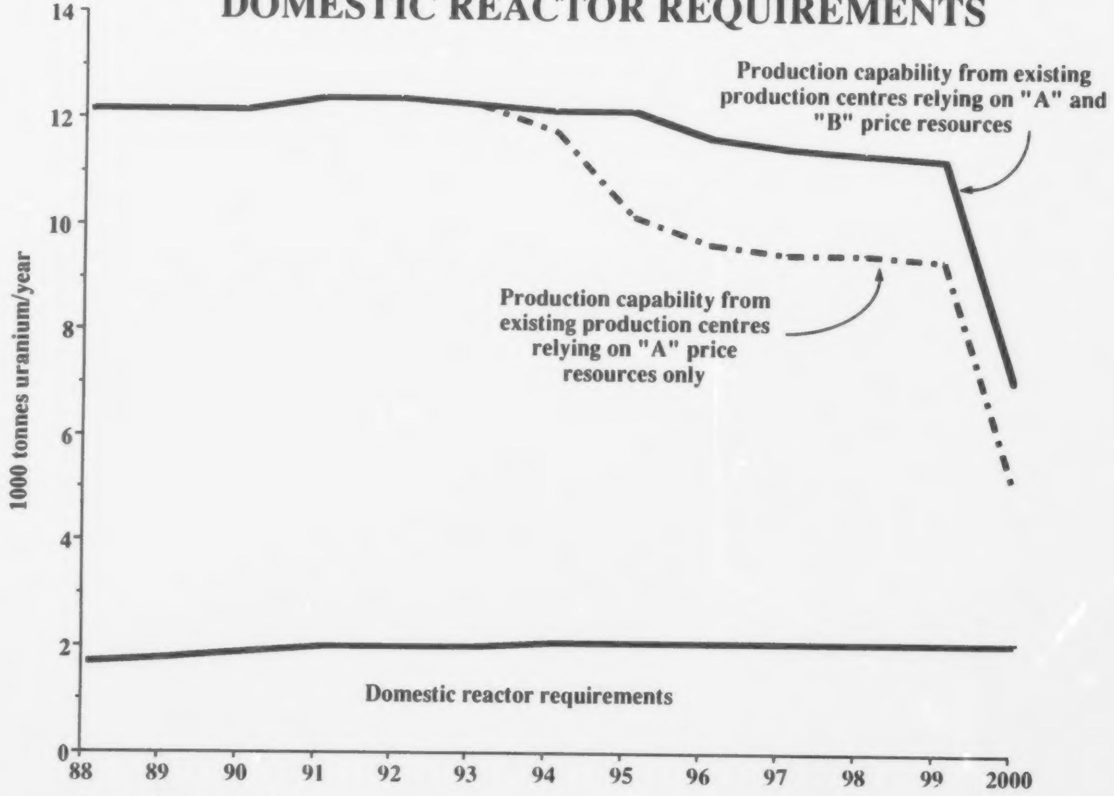


Source: Based on NEA/IAEA 1988 Data

* World Outside Centrally-Planned Economy Areas

Figure 5

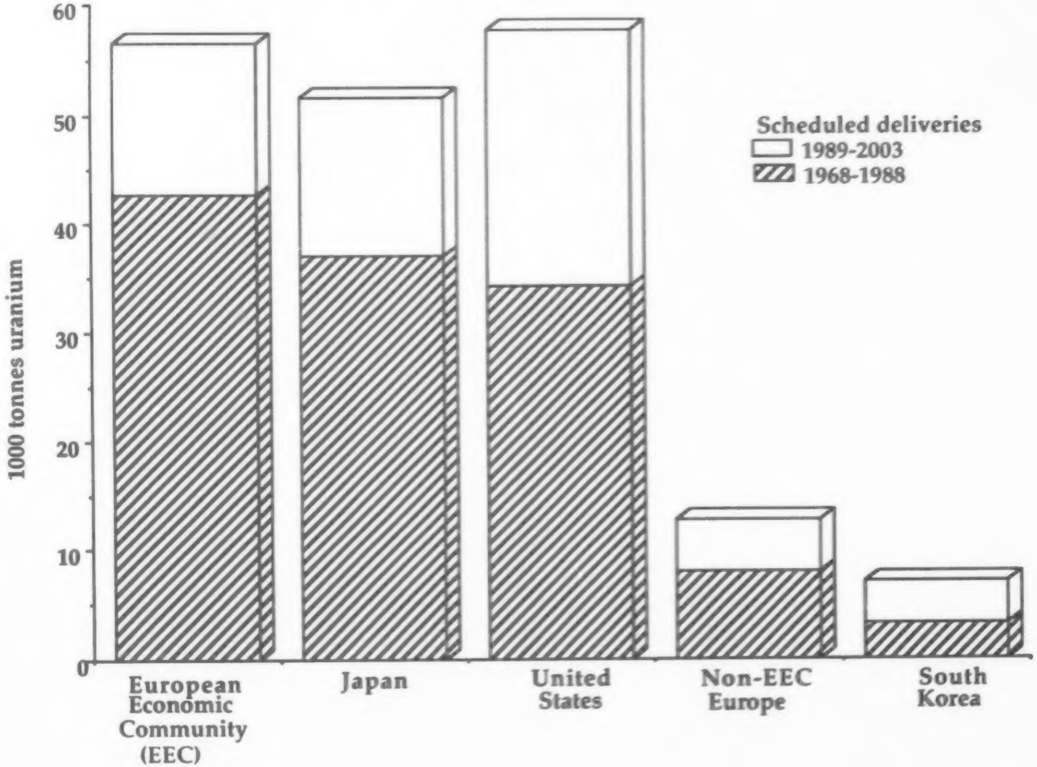
CANADIAN URANIUM PRODUCTION CAPABILITY COMPARED WITH DOMESTIC REACTOR REQUIREMENTS



Source: EMR Canada 1988

Figure 6

SCHEDULED DELIVERIES OF CANADIAN URANIUM FOR THE EXPORT MARKET



Source: EMR/UNEB

Vanadium

D.E.C. KING

Vanadium pentoxide (V_2O_5) is extracted from natural ores, vanadiferous slags and vanadium-containing petroleum residues. The basic feedstock, V_2O_5, used for the industrial production of vanadium master alloys and other vanadium products, is not currently produced in Canada. Ferrovanadium, a master alloy used in steels, is produced in Canada by Masterloy Products Limited. Canada consumed about 590 t of ferrovanadium in 1987.

World vanadium demand, which had been moderately strong for four years, gained strength in 1988. The Republic of South Africa continued to be the world's dominant producer, accounting for 65% of the world's annual production of vanadium pentoxide. The United States, which produced about 25% of the world supply, and the U.S.S.R. are net importers. Exports from the People's Republic of China, a sporadic supplier contributing about 5%, were discontinued in 1988. The shortfall in supply in 1988 combined with the strong demand resulted in a dramatic rise in the price of vanadium pentoxide. The price of ferrovanadium also increased considerably, aggravated by price increases in feedstock, aluminum reductant and other operating costs for ferrovanadium production.

The United States, which has virtually ceased production of by-product vanadium from uranium mills and vanadiferous clays, has been rebuilding its vanadium pentoxide capacity using petroleum-residues and spent catalysts as alternative feedstocks. United States companies have arranged long-term contracts for the purchase of petroleum residues from Venezuela.

An embargo against South African steel imports by the United States was initiated in the last quarter of 1986. However, South Africa continued to export steel to Asian and other countries, so that the reduction in coproduct vanadium slag output was reported to be only 10%. Nevertheless, the embargo, elimination of Chinese exports and the earlier termination of Finnish production have combined to increase the dependence in many western countries on South African vanadium.

World consumption statistics are not generally available; however, non-communist world demand for vanadium in 1988 was reported to be about 21 000 t (vanadium content), about 10% over 1987 but still well below the pre-recessionary level of 22 300 t in 1981.

CANADIAN DEVELOPMENTS

Vanadium occurrences are widespread throughout Canada. The most common type of occurrence is vanadium contained in titaniferous magnetites. The grade of the best deposits, at 0.6% is comparable to the grades of some deposits now being worked in other countries, but it is only about one-third the grade of titaniferous magnetites being mined for vanadium in the Republic of South Africa.

Bitumen in the Alberta tar sands contains only 0.02 to 0.05% V_2O_5. However, fly ash generated in bitumen extraction processes can contain up to 5% V_2O_5.

Carbovan Inc., a joint venture of Agra Industries Limited and Renzy Mines Ltd., has developed and piloted a process to extract vanadium pentoxide from fly ash generated by Suncor Inc. Construction of a demonstration plant began in mid-1988 at Fort MacMurray, Alberta. Commissioning of the plant is planned for October 1989. The design capacity of the $10 million plant is about 1000 t/y of V_2O_5.

Because there is presently no Canadian producer of vanadium feedstock, Masterloy Products Limited (Masterloy) imports all of the vanadium pentoxide necessary for its production of ferrovanadium. Masterloy's Ottawa plant has a capacity of approximately 1000 t/y of ferrovanadium. About 78% of the imported V_2O_5 comes from South Africa, the remainder from the United States and China, as available.

D.E.C. King is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 992-3733.

Masterloy supplies most of the ferrovanadium consumed in Canada, the remainder being imported, mainly from the United States. Up to one third of Masterloy's output of ferrovanadium is exported to the United States.

The principal consumers of ferrovanadium in Canada are: Stelco Inc.; The Algoma Steel Corporation, Limited; Dofasco Inc.; IPSCO Inc.; Atlas Specialty Steels Division of Rio Algom Limited; and Sydney Steel Corporation.

WORLD DEVELOPMENTS

United States

The United States lost much of its V_2O_5 production capacity when vanadium demand declined during 1982-84. Over roughly the same period, co-production of vanadium from uranium operations was lost because of shrinkage of uranium mining operations. This lost capacity has since been partially rebuilt through the increased extraction of vanadium from slags, petroleum residues, fly ash and spent catalyst. Strategic Minerals Corp. (Stratcor) installed new solvent extraction equipment at its Hot Springs, Arkansas mill, to extract vanadium from a wide range of waste materials, including petroleum residues. Some of the product is treated at Stratcor's own plant in Niagara Falls, New York, which produces ferrovanadium and vanadium aluminum. Stratcor also modified this plant to produce a proprietary vanadium master alloy called Nitrovan, beginning in 1989. In the second half of 1989 the plant will begin processing Venezuelan feedstock.

During 1988, Kerr McGee Chemical Corporation announced an expansion that will add 30% to its V_2O_5 capacity when completed in the second half of 1989.

Republic of South Africa

Vansa Vanadium S.A. Ltd. began production at its new mining property at Kennedy's Vale in October 1988. The 2 700 t/y V_2O_5 recovery plant is located at Steelpoort. South African annual production rose to an estimated 27 000 t of V_2O_5 in 1988.

People's Republic of China

China's total V_2O_5 production is reported to be about 7 000 t/y, although installed capacity is said to be nearly double this figure. Prior to ceasing its exports of vanadium pentoxide, China exported about 50% of production, according to Chinese sources. China intends to double its steel production at Panzihua to 2.8 Mt/y; the co-produced slag containing 19% V_2O_5 will be treated at the Jinzhou and Emei plants. When the new expansion is brought onstream, it should lead to an eventual 25% increase in vanadiferous slag output. Construction at Panzihua began in 1985 and is due for completion in 1990.

PRICES

Prices began to respond to the extremely tight supply/demand situation during 1988, particularly in Europe. Highveld Steel and Vanadium Corporation Ltd. of South Africa increased its producer price to US$4.50/lb. of V_2O_5 from US$2.95/lb. at the beginning of the year, while European spot prices rose to US$7.50-$8.50/lb.

Ferrovanadium prices also rose sharply, not only because of higher feedstock prices but also because of increased labour, energy and aluminum reagent costs. Ferrovanadium prices rose to US$12.50/lb. of vanadium content in the United States from $6.60/lb. at the beginning of 1988. Metals Week reported European free market prices of about $40/kg at year end.

OUTLOOK

The present high levels of vanadium demand and prices are providing an incentive to produce vanadium pentoxide from recycled materials. This trend is likely to continue if demand remains high and supply stays fairly static. However, new supplies from South Africa's Vansa operation and possibly from China may eliminate the current shortfall of vanadium pentoxide. The demand in 1988 was around 95-99 million lbs. V_2O_5, whereas production was only 89 to 92 million lbs., leaving a shortfall of about 6 million lbs. The supply situation should be somewhat eased with the introduction of vanadium pentoxide from planned new processing capacity in the United States, Canada, China and Brazil.

However, before these new supplies reach the market, the strong upward pressure on prices could continue and further price increases could occur in 1989, particularly if demand remains at the present high levels.

On the application side, there has been a gradual increase in the demand for high-strength-low-alloy steels, which are significant users of vanadium. Also, the steel industry as a whole was busier in 1988. Vanadium-bearing titanium alloys for aerospace were in high demand in 1988 as a result of increases in commercial aircraft production.

Since 1986, vanadium consumers have become even more dependent on South African supplies of feedstocks. Some lowering of this dependence could occur in the medium-term because the United States is strengthening its capacity to produce vanadium from waste materials, and other countries such as China, Canada and Brazil are bringing-on new production. Nevertheless, South Africa, with its large capacity installations already in place and with a long record of successful low cost production, technology and marketing, will probably remain the predominant western world supplier for at least the next 5 to 10 years. However, supply from this source could deteriorate due to domestic tensions or international policies relating to trade relations with South Africa.

TARIFFS

Item No.	Description	Canada			United States	EEC	Japan[1]
		MFN	GPT	USA	Canada	MFN	MFN
2825.30.00.00	Vanadium oxides and hydroxides	Free	Free	Free	12.8%	5.5%	Free
7202.92.00.00	--Ferrovanadium	10.2%	6.5%	8.1%	3.3%	4.9%	3.7%

Sources: Customs Tariffs, effective January 1989, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States (First Edition, Supplement 2) effective January 1, 1989; Official Journal of the European Communities, Vol. 30, No. L256, 1987, "Conventional" column; Custom Tariff Schedules of Japan, 1988.

[1] GATT rate is shown, lower tariff rates may apply circumstantially.

TABLE 1A. CANADA, VANADIUM IMPORTS AND EXPORTS, 1984-87

	1984	1985	1986	1987
		(tonnes)		
Imports				
Vanadium oxides				
South Africa	1 231	569	913	1 168
United States	9	2	46	136
China, People's Republic	-	48	48	66
Finland	360	504	126	36
Belgium-Luxembourg	302	-	41	-
Brazil	-	6	2	-
United Kingdom	6	-	-	-
West Germany	3	-	1	-
Other	-	-	-	5
Total	1 911	1 130^{r}	1 177	1 410
Ferrovanadium				
United States	228	171	110	183
Austria	17	17	34	17
West Germany	-	-	-	5
United Kingdom	-	-	18	-
Total	245	188	162	205
Exports				
Ferrovanadium (at 81% V content)				
United States	516	189	241	129

Sources: Statistics Canada; U.S. Bureau of Mines Import Statistics.
^{r} Revised; - Nil.
Note: Components may not add due to rounding.

TABLE 1B. CANADA, VANADIUM IMPORTS AND EXPORTS, 1988P

Item No.		1988P Jan.-Sept. (tonnes)	1988P Jan.-Sept. ($000)
Exports			
2825.30	Vanadium oxides and hydroxides		
	United States	89	90
	Tanzania	17	11
	Total	105	101
7202.92	Ferrovanadium		
	United States	5 087	246
	United Kingdom	1 066	142
	Brazil	...	3
	Total	6 154	391
Imports			
2825.30	Vanadium oxides and hydroxides		
	South Africa	859	6 971
	United States	257	2 076
	People's Republic of China	48	381
	Total	1 165	9 428
7202.92	Ferrovanadium		
	United States	176	2 393
	Total	176	2 393

Source: Statistics Canada.
P Preliminary; ... Too small to be expressed.

TABLE 2. CANADA, VANADIUM CONSUMPTION, 1985-87

	1985	1986	1987P
	(tonnes)		
Ferrovanadium			
Gross weight	656	586	754
Vanadium content	522	433	591

Source: Energy, Mines and Resources Canada.
P Preliminary.

Zinc

D. AUDET

Western world zinc consumption increased markedly in 1988 reflecting overall strength in economic activities worldwide. Metal production also increased significantly but mine production fell below the high level achieved in 1987. Zinc metal stocks fell to below the equivalent of five weeks of western world consumption. Zinc prices moved up sharply with prices on average 50% higher than in 1987. The London Metal Exchange (LME) introduced a new contract for special high grade zinc and began quoting its daily zinc prices in U.S. dollars in place of sterling. The outlook for 1989 is for slight increases in mine output, metal production and metal consumption. The market fundamentals suggest that zinc prices will hover within a range of US$0.60-0.80/lb. on the LME in 1989.

SUPPLY: CANADIAN DEVELOPMENTS

Canadian mine output declined by about 115 000 t in 1988 to about 1 365 000 t, but Canada remains by far the world's largest producer of zinc concentrates with over one quarter of western world supply. Following two years of depressed metal production due to long labour disputes, Canadian metal production reached 694 000 t which is very close to rated capacity. Canadian metal consumption remained virtually stable at an estimated 168 000 t. Details on ore grades, capacities and volume of concentrates extracted in 1987 from Canadian zinc mines are listed following the last mineral chapter of the Yearbook.

The decline in Canadian mine output is explained primarily by the closure of Cominco Ltd.'s Pine Point mine in 1987. However, milling continued until the end of the first quarter of 1988. There are significant stocks of concentrates remaining at Pine Point for delivery in future years to Cominco's Trail smelter. The latter should start receiving shipments of zinc concentrate from the Red Dog mine in Alaska in 1990.

Cominco announced its intention to expand its zinc smelter capacity in Trail to 363 000 t/y in the early 1990s. The first stage of the expansion program involves an 18 000 t/y addition of capacity beginning in 1989. A final decision on the second stage of the expansion is expected soon. Westmin Resources Limited expanded milling capacity at its Vancouver Island Myra Falls mine by 33%, equivalent to an additional 16 000 t/y of zinc.

In the Yukon, shipments of zinc concentrates were disrupted by a month-long strike at the large Faro mine of Curragh Resources Inc. Mining activities were halted but non-union staff maintained milling operations at about half the normal level. Development work is proceeding on the nearby Grum and Vangorda deposits. On the latter site, bulk concentrate testing is anticipated for next year. The company will also begin an extensive exploration program on the Cirque deposit in northern British Columbia. Production from these deposits will be gradually phased in during the 1990s as production from Faro declines.

Hudson Bay Mining and Smelting Co., Limited (HBMS) closed three small mines in Manitoba; Ghost Lake, Centennial and Anderson Lake, because ore reserves were exhausted. The company's mine output was, however, offset by increased production from other existing mines. The Ruttan mine, acquired last year from Sherritt Gordon Limited, was idle for three months during the summer because of a labour strike. Ruttan produces 15 000 t/y zinc metal content. Development work started on the Callinan zinc/copper deposit. Start up is planned for late 1989. The 15 000-18 000 t/y of zinc in concentrate will replace declining mine output in the Flin Flon area. HBMS also began an expansion program at the Chisel Lake mine in Manitoba.

D. Audet is with the Mineral Policy Sector, Energy, Mines and Resources Canada. Telephone (613) 992-4409.

HBMS has proposed to upgrade its outmoded metallurgical complex at Flin Flon, Manitoba with an investment of $130 million. The modernization would reduce operating costs and allow the company to meet Manitoba's stiffer SO_2 emission standards which will come into effect in 1994. HBMS has requested government assistance under the Acid Rain Abatement Program.

Noranda Inc., through its interest in Minnova, Inc. began commercial production at the Zenmac deposit near Winston Lake in northern Ontario. The mine has reserves of 3.4 Mt of ore grading 16% zinc and 1% copper. At a rate of 50 000 t/y of zinc content, the mine has a minimum life of 10 years. Noranda also closed the Mattabi mine in Ignace, Ontario, because ore reserves were exhausted.

At Matagami, Quebec, Noranda began commercial development of the Isle Dieu mine. Zinc output of 50 000 t/y of metal content offsets declining output from Mattagami Lake and Norita mines. The Mattagami Lake mine, with a capacity of 32 000 t/y zinc, was permanently closed due to exhaustion of ore reserves. Isle Dieu ore is processed at the Mattagami mill.

Noranda commenced a major modernization program at its Valleyfield zinc smelter where it will build a new cellhouse. Brunswick Mining and Smelting Corporation Limited, a subsidiary of Noranda, is considering the addition of a zinc roaster with the calcine to be refined at Valleyfield. Noranda has also acquired a 19.6% interest in Falconbridge Limited and it may increase its stake further in the future.

Audrey Resources Inc. temporarily suspended mining operations at its Mobrun mine for the construction of a mill and to sink a new shaft to enable additional underground development.

East-West Minerals NL officially opened the Caribou mine near Bathurst, New Brunswick. The company uses a sophisticated milling process to treat the fine-grained complex lead/zinc/copper ore to produce a bulk lead-zinc concentrate which is exported to smelters in Europe. Annual output is anticipated to be 125 000 t/y grading 34% zinc and 12% lead.

Canadian Reserves

Canada is the world's largest zinc mine producer. Mine production peaked in 1987 at 1 480 000 t metal content. Notwithstanding the opening of several new mines in 1988 and the prospect of additional mines opening in the future, total production is expected to fall again in 1989 and more rapidly after 1994 because of gradual ore reserves exhaustion at the larger mines. To maintain production after 1994, major new zinc deposits are required in the immediate future given the long lead time to turn discoveries into mines.

This decade has seen a concentration of exploration efforts on gold and a general neglect of other base-metal exploration including zinc. This has been attributable to a number of factors including the severe recession of 1981-82 and the low base metal prices which prevailed for several years. As a result, discoveries of zinc reserves during the 1981-85 period were only one quarter those in the 1976-81 period. Recent improvements in zinc market fundamentals are expected to stimulate further exploration activities.

SUPPLY: WORLD DEVELOPMENTS

Western world zinc production declined by about 4.6% in 1988. The strongest reduction in mine production occurred in Canada due to ore reserve exhaustion and in Peru due to a range of supply problems. Low mine output was also recorded in Japan, Federal Republic of Germany (FGR) and South Africa. Partly offsetting these losses, mine output rose in the United States, Australia and Spain.

In Peru, mine output was plagued by a series of interruptions due to labour strikes, interruption of power supplies and a shortage of foreign exchange necessary to buy essential spare parts and equipment. In January, the Cerro de Pasco and Youricocha mines were temporarily closed by a strike. In May, a strike at the Casapalca mine forced Empresa Minera del Centro del Peru S.A. (Centromin Peru S.A.) to declare force majeure on shipments of zinc concentrates. In June, the Cia Minero Melpo mine was paralyzed by a strike. In July, all Peruvian miners and metallurgical workers went on strike for a two day national protest. In November and December, another general strike paralyzed the majority of Peru's mines and the two smelters. It is estimated that Peru's mine production declined by about 20% because of labour strikes.

In Japan, declining mine output is continuing a trend which began in 19[illegible]. Since then, mine production has declined by 100 000 t/y due to ore reserve exhaustion at several small mines. The reduction in production was less pronounced in 1988 than in 1987.

In the Federal Republic of Germany, Preussag AG's Rammelsberg mine closed permanently and the Bad Grund and Meggen mines operated well below capacity. In Sweden, three small mines operated by Boliden Mineral AB were closed due to ore reserve exhaustion. The lost production was however offset by increased production from other mines. In South Africa, the Prieska mine is to close in 1989 and production fell significantly in 1988.

In Australia, the Cadjebut mine opened in May and full capacity production of 41 000 t/y of zinc content is anticipated for early 1989. Mine production increases were experienced in several existing operations. Australian mine production is expected to increase significantly next year with a major expansion at the Hellyer project and several other new mines having a combined new capacity of some 300 000 t/y of zinc.

In United States, mine production is expanding and it is expected to double after 1990 when the Red Dog mine will start up. The Bunker Hill mine in Idaho reopened with limited production in 1988. The mine had been closed since 1981. ASARCO Incorporated's West Fork mine in Missouri expanded production with an additional 20 000 t/y of zinc capacity. Pegasus Gold Inc.'s Montana Tunnels mine also expanded zinc production. The company is specializing in gold production extracted from complex metallurgical ore. In 1989, mine production will rise with full production at the Montana Tunnels and the Bunker Hill mines.

Smelting

Western world refined zinc production increased again in 1988 following a 4% increase in 1987. Production increased slightly in all regions of the world with major increases occurring in Canada, Republic of Korea and Spain. Smelting capacity also expanded with several expansion projects around the world.

In Europe, smelting capacity was slightly reduced with the permanent closure of Preussag's 70 000 t/y capacity Harlingerode smelter. Conversely, Asturiana de Zinc S.A., in Spain, expanded its 200 000 t/y smelter by an additional 30 000 t/y and Outokumpu Oy, in Finland, added 10 000 t/y to its 170 000 t/y smelter. In France, Vieille-Montagne SA completed the expansion of the Auby plant which offset the closure of the Viviez smelter last year.

Elsewhere, in Brazil, Cia Paraibuna de Metais SA completed its smelter expansion to 60 000 t/y capacity. In Japan, two expansions occurred: 20 000 t/y were added by the Hachinohe Smelting Co. Ltd. at Aomori and 9 000 t/y by the Mitsubishi Metal Corporation at its Akita plant. In Thailand, the 70 000 t/y Padaeng Industry Co. Ltd.'s smelter added 10 000 t/y in capacity.

In Europe, talks initiated in 1987 between the five larger European metal producers on how excess smelting capacity could be curtailed were not resumed in 1988. However, changes in European corporate structure have been significant. Société Générale de Belgique increased its equity in Vieille Montagne, the world's leading zinc smelter with 400 000 t/y in two plants, to 90% from 52%. Société Générale plans to acquire the remaining 10%. The combined capacities include two smelters, a zinc mine in Sweden, and an interest in Union Zinc Inc., the nonferrous arm of Société Générale in the United States which includes the Elmwood-Gordonsville mine and the Clarksville smelter in Tennessee. Also, Preussag of Germany and Société minière et métallurgique de Peñarroya S.A. (Peñarroya) of France agreed to merge their zinc, lead and high purity metals operations into a newly formed group called Metaleurop SA. The venture does not include Preussag's existing mining operations nor Peñarroya's Crotone smelter. The new entity will control about 300 000 t/y of zinc smelting capacity. The proposed merger is awaiting EEC approval.

Elsewhere, Northern Broken Hill Holding Ltd. and CRA Limited have merged their worldwide lead and zinc operations into renamed Pasminco Ltd. The companies were already partners through The Broken Hill Associated Smelters Pty. Ltd. The merger has been approved in Australia by the Trade Practices Commission.

In Peru, the Cajamarquilla smelter was substantially affected by interruptions of power supply caused by terrorist actions in April and August. The smelter produced below capacity for some time and force majeure was declared on its shipments in August. Similarly, Centromin Peru S.A.'s La Oroya smelter also produced below capacity. By year-end, the general strike paralyzed the two smelters and force majeure was declared on domestic and foreign shipments. Although, labour problems may be resolved next year, Peru's zinc production is likely to be adversely affected by shortages of parts due to foreign exchange difficulties.

CONSUMPTION AND USES

Western world zinc consumption surged in 1988 reflecting the buoyant state of the economies in most of the industrialized countries and the expansion being achieved in newly industrializing and developing countries. The strength of zinc metal demand reflects continuing growth in the use of galvanized steel in automotive applications and in the construction industry. Galvanizing steel is the most cost effective means of protecting steel against corrosion. Use of zinc in galvanizing is growing and there is good potential for other successful applications.

There was a noticeable change in the distribution of western world consumption of refined zinc between 1975 and 1988. In 1975, consumption in developing countries accounted for about 15% of the total, whereas it now accounts for about 24%. During that period over 40% of total growth in zinc consumption occurred in developing countries. Consumption tripled in the Asian region and doubled in Central and South America, but remained virtually stable in the African region excluding South Africa.

Prospects are for continued growth in galvanizing applications and faster growth of zinc consumption in developing countries than in developed states.

Zinc is a widely used metal, based on its low melting point which facilitates shaping by casting; its high electrochemical activity which provides cathodic corrosion and contact protection (galvanizing) for iron and steel products; and its ability to alloy readily with copper to make brass. About 40% of zinc is used in galvanizing. The automotive industry is the largest consumer of galvanized steel. Corrosion is a major concern of car buyers and manufacturers have responded by increasing the use of electrogalvanizing for exposed painted parts requiring high surface quality, and of hot-dipped galvanizing for unpainted parts.

Galvanized products such as structural components, roofing, siding and reinforcing bars are used in construction. Zinc and zinc-aluminum thermally sprayed coatings are utilized for long-term corrosion protection of large steel structures. The world's largest on-site thermally sprayed structure is the Pierre Laporte bridge in Quebec City spanning the St. Lawrence River.

Brass and bronze, as used in plumbing fittings, heating and air conditioning components and other products, account for about 20% of zinc consumption, as does the diecasting industry for products such as builders' hardware and fittings on automobiles. The balance is used for such items as zinc semi-manufactures, oxides, chemicals and dust. Zinc oxide is an important component in the manufacture of tires and rubber products.

Galfan, a new and improved galvanizing alloy developed by the International Lead and Zinc Research Organization (ILZRO), was first used commercially in 1983 in Japan. The alloy contains about 90% zinc, 5% aluminum and a small but significant amount of rare earth metals. The new alloy outperforms conventional galvanizing and Galvalume in corrosion resistance and several other characteristics. Another advantage is that only minor modifications are necessary to adapt existing galvanizing lines compared with the major cost of converting a line for Galvalume. Galvalume (55% aluminum, 43.4% zinc and 1.6% silicon), was developed by Bethlehem Steel Corporation and introduced to the U.S. market in 1976 for specialized applications. These alloys are complementary to galvanizing and increase the potential market for zinc.

INTERNATIONAL LEAD ZINC STUDY GROUP

The International Lead and Zinc Study Group was formed in 1959 to improve market information and to provide opportunities for regular intergovernmental consultations on lead and zinc markets. Particular attention is given to providing regular and frequent information on supply and demand and its probable development.

The Study Group is headquartered in London, England. Its membership includes most major lead and zinc producing and consuming countries. While it has an extensive information gathering and dissemination role, the Group has no market intervention powers. It holds a general session each year in the fall. Member countries' delegations generally include industry representatives as advisors. It is noteworthy that China joined the organization in 1987, as did the Republic of Korea. Canada has been an active member since its inception.

PRICES AND STOCKS

In 1988, average zinc prices surged by about 50% compared to 1987 and various changes occurred in zinc pricing mechanisms.

Zinc prices on the London Metal Exchange (LME) began the year at US39¢/lb. Strong consumption growth for several years had depleted stocks to the equivalent of about six weeks of western world consumption. With smelters operating at close to capacity and the growing concern about the short-term availability of concentrates, zinc prices rose to the US60¢/lb. level during the spring and the summer months. A brief strike at the Faro mine temporarily exacerbated fears about zinc being in short supply. Despite the resumption of work at Faro, further reductions in stocks during the fall pushed metal prices higher. By year-end, the long Peruvian national strike also contributed to maintaining zinc prices above the US70¢/lb. mark. The effect of higher zinc prices was partly offset by a depreciated U.S. dollar which, to some extent, helped maintain the position of zinc relative to competing materials in countries with stronger currencies.

The LME introduced a new futures contract for Special High Grade (SHG) zinc with a minimum purity of 99.995% in September, and cash transactions began in December. The new grade reflects technological changes in the use of zinc and growing demand by users for higher purity metal. Also in September, the Exchange began quoting its daily High Grade zinc contracts in U.S. dollars in place of sterling so that all three main zinc prices are now quoted in the same currency.

The introduction of SHG trading on the LME challenged the European Producer Price (EPP) as the basis for purchases of zinc concentrates and sales of zinc metal. The EPP, for Good Ordinary Brand (GOB) at 98.5% purity, was introduced in 1964 to provide zinc users with more price stability. Most smelters decided to shift from the EPP to the SHG price effective January 1, 1989.

Total reported stocks of refined zinc metal remained fairly stable during the 1984-86 period, hovering around an equivalent of 6.5 weeks of western world consumption. Total stocks fell below the six week level in 1987 and below five weeks in 1988. The reduction in stocks is largely attributable to a drop in metal holdings by the producers. The consumers on the other hand have increased their holdings slightly. The relatively high metal prices and expectations that prices will fall have discouraged consumers from building up more inventories.

On the LME, a major issue for the success of SHG trading had been whether the LME would have enough SHG inventory to ensure sufficient liquidity in the cash market. Despite sizeable delivery of SHG zinc to LME warehouses in late November and December, transactions in the new contracts have been slow to develop.

HEALTH AND ENVIRONMENT

Every form of life, from micro-organisms to man, requires an adequate dietary amount of zinc. Man requires about 15 mg daily. Zinc deficiencies retard growth and could be a cause of abnormalities in humans. Zinc deficiency in soils has considerable economic implications in agriculture as zinc helps prevent diseases.

Zinc concentrates are transformed into zinc metal in metallurgical plants using either pyrometallurgical or the hydrometallurgical processes. The hydrometallurgical (roast-leach-electrolysis) process has become the most important zinc recovery process because of lower unit operating costs, improved zinc recovery and greater amenability to environmental controls. The pyrometallurgical process involves zinc distillation in horizontal or vertical retort furnaces which are more labour intensive and costly. In Canada, all of the four zinc smelters use the roast-leach-electrolysis process and three of them recover a very high percentage of the sulphur content of feed in the form of sulphuric acid or elemental sulphur. Proposed modernization of the HBMS smelter of Flin Flon, would virtually eliminate SO_2 emissions from the zinc circuit to meet Manitoba's SO_2 emission regulations for the plant.

OUTLOOK

Consumption of refined zinc is expected to grow further in 1989, reflecting the anticipated continuing overall economic expansion throughout the world. As a cautionary note, however, increased interest rates in 1988 and the prospect of higher rates in 1989, suggest that construction activities and consumption of finished products might be adversely affected.

In 1989, little expansion is expected in mine production, and recurrent mine supply disruptions caused by unpredictable labour strikes or equipment failures are likely to restrain refined zinc production. Unless demand slows in the latter half of 1989, the deficit in refined zinc supply can be filled only by further reductions in stocks and prices can be expected to remain very strong through 1989. Prices are likely to hover within a range of US60¢-80¢/lb. on the LME, with the possibility of even higher price spikes during the first half.

Dollar-denominated zinc prices will also be influenced by the anti-inflation policy of the U.S. Administration. Higher U.S. interest rates would tend to push up the U.S. dollar, thereby compounding the zinc price increases denominated in other currencies.

Prospects for the early 1990s change significantly due to the opening or expansion of large mines which will ensure that the market will be well supplied. Zinc prices are therefore anticipated to decline to reflect the prevailing market conditions. Additional new smelting capacity is also anticipated in the early 1990s, primarily in the developing countries.

Zinc consumption in the western world is projected to grow at an average of 1.3% to the end of this century. While zinc in galvanizing is expected to grow faster, the prospect for the other zinc uses is not buoyant. Zinc in die-casting is expected to continue to decline because of competition from alternative materials. The above consumption growth rate takes into account a cyclical downturn of worldwide economies in the early 1990s.

In Canada, mining production should stabilize at a lower level after 1989. The Tecam mine at Daniel's Harbour, Newfoundland, is expected to close in 1989 due to exhaustion of ore reserves. In the early 1990s, a number of new deposits will be developed but their output will be offset by declining output from existing mines. The decline in output, due to depleting ore reserves, will be more pronounced after 1994. Unless new large zinc deposits are discovered in the short term, Canadian mines will decline significantly in the later 1990s.

TARIFFS

		Canada			United States	EEC	Japan[1]
Item No.	Description	MFN	GPT	USA	Canada	MFN	MFN
2603.00.00	Copper ores and concentrates	Free	Free	Free	Free	Free	Free
2603.00.00.30	-----Zinc content	Free	Free	Free	Free	Free	Free
2607.00.00	Lead ores and concentrates	Free	Free	Free	1.5¢/kg on lead content	Free	Free
2607.00.00.30	-----Zinc content	Free	Free	Free	Free	Free	Free
2608.00.00	Zinc ores and concentrates	Free	Free	Free	1.5¢/kg on lead content	Free	Free
2608.00.00.30	-----Zinc content	Free	Free	Free	Free	Free	Free
2616.10.00	Silver ores and concentrates	Free	Free	Free	Free	Free	Free
2616.10.00.30	-----Zinc content	Free	Free	Free	Free	Free	Free
26.20	Ash and residues (other than from the manufacture of iron or steel), containing metals or metallic compounds						
	-Containing mainly zinc						
2620.11.00.00	--Hard zinc spelter	Free	Free	Free	1.3%	Free	Free
2817.00.00.10	-----Zinc oxide	10.5%	Free	9.4%	Free	11%	6.5%
2817.00.00.20	-----Zinc peroxide	10.5%	Free	9.4%	Free	11%	6.5%
28.33	Sulphates; alums; peroxosulphates (persulphates)						
2833.26.00.00	--Of zinc	9.2%	6%	7.3%	1.2%	9%	5.8%
79.01	Unwrought zinc						
	-Zinc, not alloyed						
7901.11.00.00	--Containing by weight 99.99% or more of zinc	Free	Free	Free	1.3%	3.5%	8 yen/kg
7901.12.00.00	--Containing by weight less than 99.99% of zinc	Free	Free	Free	17.1%	3.5%	8 yen/kg
7901.20	-Zinc alloys						
7901.20.10.00	---Containing by weight 90% or more but less than 97.5% of zinc	Free	Free	Free	17.1%	3.5%	7.8 yen/kg
7901.20.20.00	---Containing by weight less than 90% of zinc	17.5%	11.5%	15.7%	17.1%	3.5%	7.2-7.8 yen/kg
7902.00.00.00	Zinc waste and scrap	Free	Free	Free	Free	Free	1.9%
79.03	Zinc dust, powders and flakes						
7903.10.00.00	-Zinc dust	Free	Free	Free	0.6¢/kg	4.4%	5.8%
7903.90	-Other						
7903.90.10.00	---Powders, not alloyed	4%	Free	3.6%	0.6¢/kg	4.4%	5.8%
7903.90.20.00	---Alloyed powders; flakes	10.2%	6.5%	9.1%	8.5%	4.4%	5.8%
7904.00	Zinc bars, rods, profiles and wires						
7904.00.10.00	---Bars, rods or profiles, containing by weight 90% or more of zinc	Free	Free	Free	3.7%	8%	4.8%

TARIFFS (cont'd)

Item No.	Description	Canada MFN	Canada GPT	Canada USA	United States Canada	EEC MFN	Japan[1] MFN
7904.00.21	----Bars, rods or profiles; wire, coated or covered	10.2%	6.5%	9.1%	3.7%	8%	4.8%
7904.00.21.10	-----Bars and rods	10.2%	6.5%	9.1%	3.7%	8%	4.8%
7904.00.21.20	-----Profiles	10.2%	6.5%	9.1%	3.7%	8%	4.8%
7904.00.21.30	-----Wire	10.2%	6.5%	9.1%	3.7%	8%	4.8%
7904.00.22.00	----Wire, not coated or covered	8%	5%	7.2%	3.7%	8%	4.8%
7905.00	Zinc plates, sheets, strip and foil						
	---Containing by weight 90% or more of zinc						
7905.00.11.00	----Of a thickness exceeding 0.15 mm but less than 4.75 mm, for making offset printing plates; of a thickness exceeding 0.15 mm but less than 4.75 mm, not polished, coated on one side with acid-resisting material, imported for use by grinders and polishers, to be prepared for use in photo-engraving	Free	Free	Free	3.7%	8%	7.2%
7905.00.19.00	----Other	5.5%	3.5%	4.9%	3.7%	8%	7.2%
7905.00.20.00	---Containing by weight less than 90% of zinc	10.2%	6.5%	9.1%	3.7%	8%	7.2%
7906.00.00.00	Zinc tubes, pipes and tube or pipe fittings (for example, couplings, elbows, sleeves)	10.2%	6.5%	9.1%	3.4%	8%	4.8%
79.07	Other articles of zinc						
7907.10.00	-Gutters, roof capping, skylight frames and other fabricated building components	10.2%	6.5%	9.1%	5.1%	7%	4.9%
7907.90	-Other						
7907.90.10.00	---Anodes for electroplating	Free	Free	Free	3-5.1%	7%	5.8%
7907.90.20.00	---Discs or slugs, containing by weight 90% or more of zinc	5.5%	3.5%	4.9%	3-5.1%	7%	5.8%
7907.90.90	---Other	10.2%	6.5%	9.1%	3-5.1%	7%	5.8%
7907.90.90.11	------Not alloyed	10.2%	6.5%	9.1%	3-5.1%	7%	5.8%
7907.90.90.12	------Alloyed	10.2%	6.5%	9.1%	3-5.1%	7%	5.8%

Sources: Customs Tariffs, effective January 1989, Revenue Canada, Customs and Excise; Harmonized Tariff Schedule of the United States (First Edition, Supplement 2) effective January 1, 1989; Official Journal of the European Communities, Vol. 30, No. L256, 1987, "Conventional" column; Custom Tariff Schedules of Japan, 1988.

[1] GATT rate is shown, lower tariff rates may apply circumstantially.

Note: Where there is a tariff "range" a complete match of the HS code was not available, therefore, the high and low for the product in question is shown.

TABLE 1A. CANADA, ZINC PRODUCTION, TRADE AND CONSUMPTION, 1985-87

	1985		1986		1987	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Production						
All forms[1]						
Newfoundland	32 730	41 043	5 712	6 940	7 643	9 737
New Brunswick	197 503	247 669	161 807	196 595	180 298	229 699
Quebec	75 812	95 068	37 126	45 108	91 139	116 111
Ontario	280 475	351 716	265 248	322 276	294 309	374 950
Manitoba	64 689	81 120	61 463	74 677	63 551	80 964
Saskatchewan	5 663	7 101	3 527	4 286	1 764	2 247
British Columbia	108 072	135 522	137 583	167 163	114 117	145 385
Yukon	108	137	50 634	61 521	147 045	187 336
Northwest Territories	284 223	356 415	265 073	322 064	258 070	328 781
Total	1 049 275	1 315 791	988 173	1 200 630	1 157 936	1 475 211
Mine output[2]	1 172 238		1 290 765		1 481 544	
Refined[3]	692 406		570 981		609 909	
Exports						
Zinc contained in ores and concentrates						
Belgium-Luxembourg	185 509	98 868	166 247r	84 217r	259 165	131 887
Japan	28 060	15 749	68 309r	37 451r	111 248	46 600
France	29 138	16 369	43 541	21 185	47 747	21 647
Italy	21 340	10 461	39 993	16 954	47 822	20 437
United States	45 593r	26 054r	12 945r	6 770r	33 792	17 519
Other countries	86 463r	43 903r	119 214r	62 429r	113 411	53 003
Total	396 103	211 403	450 249	229 007	613 185	291 094
Zinc alloy scrap, dross and ash[4]						
United States	7 025	4 967	7 558	4 884	10 379	6 028
Taiwan	860	585	6 086	3 538	7 096	3 844
India	429	249	669	373	1 674	1 136
West Germany	7 477	3 462	5 781	2 518	2 142	640
Belgium-Luxembourg	274	172	108	167	556	449
Other countries	2 014r	1 198r	2 950r	1 997r	2 649	874
Total	18 079r	10 634	23 152	13 477r	24 496	12 971
Zinc dust and granules						
United States	5 581	7 413	3 832	5 727	4 122	6 362
Chile	-	-	-	-	19	44
Philippines	-	-	-	-	26	39
West Germany	93	62	-	-	72	27
India	-	-	-	-	58	25
Other countries	2 394r	2 130r	94r	185r	71	33
Total	8 068	9 604	3 926	5 912	4 368	6 530

TABLE 1A. (cont'd)

	1985		1986		1987	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Exports (cont'd)						
Zinc blocks, pigs and slabs						
United States	371 156	438 913	333 123	344 577	342 970	372 126
United Kingdom	41 089	44 191	29 068	28 881	26 157	26 437
Taiwan	10 776	11 735	13 245	12 267	11 701	11 958
People's Republic of China	44 059	44 960	2 281	2 253	10 481	9 481
Singapore	852	974	1 491	1 353	5 013	5 007
Other countries	87 689^{r}	94 685^{r}	47 968^{r}	43 169^{r}	44 905	45 597
Total	555 621	635 457	427 176	432 500	441 227	470 605
Zinc fabricated material, n.e.s.						
United States	1 234	3 672	1 048	3 982	963	3 170
Hong Kong	1	4	3	10	2 366	2 619
People's Republic of China	-	-	-	-	577	615
Taiwan	-	-	-	-	203	219
United Kingdom	17	85	3	17	43	201
Other countries	27^{r}	47^{r}	72^{r}	73^{r}	310	405
Total	1 279	3 808	1 126	4 081	4 462	7 230
Imports						
Zinc in ores, concentrates and scrap	17 120	9 291	36 412^{r}	16 819^{r}	31 949	17 409
Zinc oxide and peroxide	1 304	1 565	1 626	1 365	2 228	2 028
Zinc sulphate	1 590	951	2 189	1 262	2 663	1 436
Zinc dust and granules	947	1 678	797	1 341	668	1 111
Zinc slabs, blocks, pigs and anodes	1 814	2 127	9 319	11 011	11 033	14 364
Zinc bars, rods, plates, strip and sheet	444	1 277	466	1 185	1 963	3 400
Zinc slugs, discs and shells	-	-	21	13	8	5
Zinc fabricated materials, n.e.s.	523	1 843	982	3 186	1 024	3 288
Total	23 742	18 733	51 812^{r}	36 183^{r}	51 536	30 114

	1985			1986			1987P		
	Primary	Secondary	Total	Primary	Secondary	Total	Primary	Secondary	Total
				(tonnes)					
Consumption[5]									
Zinc used for, or in the manufacture of:									
Copper alloys (brass, bronze, etc.)	7 348)			9 973)			10 848)		
Galvanizing: electro	2 980)	1 279	77 513	3 767)	3 725	79 887	4 006)	x	x
hot dip	65 906)			62 422)			65 600)		

Zinc die-cast alloy	14 152	x	x	12 297	x	x	13 708	x	x
Other products (including rolled and ribbon zinc, zinc oxide)	27 015	x	x	30 080	x	x	29 787	x	x
Total	117 401	5 855	123 256	118 539	7 576	126 115	123 949	7 188	131 137
Consumer stocks, year-end	11 210	697	11 907	11 437	423	11 860	14 164	535	14 699

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] New refined zinc produced from domestic primary materials (concentrates, slags, residues, etc.) plus estimated recoverable zinc in ores and concentrates shipped for export. [2] Zinc content of ores and concentrates produced. [3] Refined zinc produced from domestic and imported ores. [4] Gross weight. [5] Consumer survey does not represent 100% of Canadian consumption and is therefore consistently less than apparent consumption.

P Preliminary; r Revised; - Nil; n.e.s. Not elsewhere specified; x Confidential.

Note: Components may not add due to rounding.

TABLE 1B. CANADA, ZINC PRODUCTION AND TRADE, 1988P

Item No.		1988P	
		(tonnes)	($000)
Production			
	All forms[1]		
	Newfoundland	29 906	49 256
	Nova Scotia	x	x
	New Brunswick	230 125	379 016
	Quebec	73 440	120 956
	Ontario	333 235	548 838
	Manitoba	57 182	94 179
	Saskatchewan	x	x
	British Columbia	119 522	196 853
	Yukon	118 325	194 881
	Northwest Territories	290 000	477 630
	Total	1 253 580	2 064 647
	Mine output[2]	1 351 664	..
	Refined[3]	703 206	..
Exports		**(Jan.-Sept.)**	
2608.00.30	Zinc content in zinc ores and concentrates		
	Belgium	258 526	144 104
	Japan	80 056	41 459
	West Germany	58 085	29 381
	South Korea	53 944	29 032
	United States	30 491	13 851
	France	27 136	12 563
	Italy	21 450	11 090
	Bulgaria	17 943	12 847
	Other countries	74 355	39 047
	Total	621 986	333 374
2603.00.30	Zinc content in copper ores and concentrates		
	Japan	1 534	1 090
	Total	1 534	1 090
2607.00.30	Zinc content in lead ores and concentrates		
	United States	110	55
	Total	110	55
2620.11	Ash and residues containing hard zinc spelter		
	United States	79	59
	United Kingdom	95	29
	France	74	26
	Other countries	86	19
	Total	334	133
2620.19	Ash and residues containing mainly zinc n.e.s.		
	United States	3 737	1 876
	India	581	378
	France	401	192
	Taiwan	207	218
	Belgium	44	184
	Other countries	824	372
	Total	5 794	3 220

TABLE 1B. (cont'd)

Item No.		1988P Jan.-Sept.	
		(tonnes)	($000)
Exports (cont'd)			
7901.11	Zinc not alloyed unwrought containing by weight 99.99% or more of zinc		
	United States	168 983	204 982
	United Kingdom	12 759	13 617
	People's Republic of China	8 599	8 193
	Japan	7 108	7 776
	Taiwan	6 784	7 342
	Indonesia	4 524	4 444
	Hong Kong	3 699	3 961
	Malaysia	2 430	2 352
	Switzerland	1 688	1 969
	Singapore	1 670	1 633
	Philippines	1 532	1 458
	India	1 016	1 122
	Ecuador	1 000	1 019
	Other countries	3 243	3 483
	Total	225 035	263 351
7901.12	Zinc not alloyed unwrought containing by weight less than 99.99% of zinc		
	United States	149 970	201 572
	Taiwan	10 637	12 635
	United Kingdom	7 884	11 597
	Japan	7 387	9 152
	Indonesia	4 049	4 985
	Italy	2 955	3 910
	Hong Kong	3 299	3 987
	Philippines	2 840	3 162
	Singapore	2 229	2 893
	Israel	1 844	2 572
	Other countries	8 490	10 330
	Total	201 584	266 795
7901.20	Zinc alloys unwrought		
	United States	12 377	14 667
	Other countries	3 191	3 625
	Total	15 568	18 292
7902.00	Zinc waste and scrap		
	Taiwan	5 721	3 266
	United States	4 371	3 055
	Other countries	1 699	799
	Total	11 791	7 120
7903.10	Zinc dust		
	United States	3 560	6 195
	Other countries	116	195
	Total	3 676	6 390
7903.90	Zinc powders and flakes		
	United States	286	283
	Other countries	122	78
	Total	408	361
7904.00	Zinc bars, rods, profiles and wire		
	United States	73	111
	Total	73	111

TABLE 1B. (cont'd)

Item No.		1988P Jan.-Sept.	
		(tonnes)	($000)
Exports (cont'd)			
7905.00	Zinc plates, sheets, strip and foil		
	United States	1 231	1 435
	West Germany	18	3
	Total	1 249	1 438
7906.00	Zinc pipes or tubes and fittings		
	United States	5	20
	Other countries	6	28
	Total	11	48
7907.90	Articles of zinc n.e.s.		
	United States	1 515	4 980
	Other countries	923	871
	Total	2 438	5 851
Imports			
2608.00.00.30	Zinc content in zinc ores and concentrates	22 408	14 783
2603.00.00.30	Zinc content in copper ores and concentrates	26	43
2607.00.00.30	Zinc content in lead ores and concentrates	944	1 419
2620.19	Ash and residues containing mainly zinc, n.e.s.	96	115
2817.00	Zinc oxide; zinc peroxide	916	1 320
2833.26	Zinc sulphate	1 689	1 015
7901.11	Zinc not alloyed unwrought containing by weight 99% or more of zinc	1 376	1 765
7901.12	Zinc not alloyed unwrought containing by weight less than 99.99% of zinc	731	1 187
7901.20	Zinc alloys unwrought	3 307	5 482
7902.00	Zinc waste and scrap	1 912	1 424
7903.10	Zinc dust	517	751
7903.90	Zinc powders and flakes	172	349
7904.00	Zinc bars, rods, profiles and wire	820	1 349
7905.00	Zinc plates, sheets, strip and foil	542	994
7906.00	Zinc pipes or tubes and fittings	195	687
7907.90	Articles of zinc, n.e.s.	1 829	6 984
	Total	37 480	39 667

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] New refined zinc produced from domestic primary materials (concentrates, slags, residues, etc.) plus estimated recoverable zinc in ores and concentrates shipped for export. [2] Zinc content of ores and concentrates produced. [3] Refined zinc produced from domestic and imported ores.

P Preliminary; x Confidential; .. Not available or not applicable; n.e.s Not elsewhere specified.

Note: Components may not add due to rounding.

TABLE 2. CANADA, ZINC PRODUCTION, EXPORTS AND DOMESTIC SHIPMENTS, 1970, 1975, 1981-87

	Production		Exports		
	All Forms[1]	Refined[2]	In Ores and Concentrates	Refined[2]	Total
			(tonnes)		
1[illegible]	1 135 714	417 906	809 248	318 834	1 128 082
19[illegible]	1 055 151	426 902	705 088	247 474	952 562
1981	911 178	618 650	516 210	453 526	969 736
1982	965 607	511 870	457 751	470 390	928 141
1983	987 713	617 033	626 178	500 448	1 126 626
1984	1 062 701	689 841r	539 633	529 659	1 069 292
1985	1 049 275	692 406	396 103	555 621r	951 724
1986	988 173	570 981	450 249r	427 176	877 425r
1987	1 157 936	609 909	613 185	441 227	1 054 412

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] New refined zinc produced from domestic primary materials (concentrates, slags, residues, etc.) plus estimated recoverable zinc in ores and concentrates shipped for export. [2] Refined zinc produced from domestic and imported ores.
r Revised.

TABLE 3. WESTERN WORLD, PRIMARY ZINC STATISTICS, 1985-88

	1985	1986	1987	1988
		(000 tonnes)		
Mine Production (Zinc Content)	5 150	5 097	5 324	5 123
Metal Production	4 996	4 854	5 047	5 220
Metal Consumption	4 744	4 885	5 033	5 283

Source: International Lead and Zinc Study Group.

TABLE 4. WESTERN WORLD ZINC MINE PRODUCTION, 1986-88

	1986	1987	1988[2]
	(000 tonnes)		
Europe			
Germany, F.R.	104	99	
Ireland	182	177	
Spain	227	273	
Sweden	219	219	
Yugoslavia	90	71	
Others	260	250	
Total	1 082	1 089	1 071
Africa			
South Africa[1]	136	153	
Zaire	81	87	
Zambia	51	56	
Others	31	29	
Total	299	325	
Oceania			
Australia	665	721	750
Americas			
Brazil	93	98	
Canada	1 291	1 500	1 360
Mexico	285	282	295
Peru	598	619	496
United States	221	233	264
Others	110	108	
Total	2 598	2 840	
Asia			
Japan	222	166	147
Others	231	229	
Total	453	395	
Total Western World	5 097	5 370	5 123

Source: International Lead and Zinc Study Group.

[1] Includes Namibia. [2] Preliminary, not available separately.

TABLE 5. WESTERN WORLD ZINC METAL PRODUCTION, 1986-88

	1986	1987	1988[2]
	(000 tonnes)		
Europe			
Belgium	269	284	
Finland	155	152	
France	257	249	
Germany, F.R.	371	378	
Italy	230	247	
Netherlands	198	205	
Norway	90	117	
Spain	202	224	
United Kingdom	86	81	
Yugoslavia	102	122	
Others	30	30	
Total	1 990	2 089	2 142
Africa			
South Africa[1]	81	96	
Zaire	64	55	
Others	51	40	
Total	196	191	
Americas			
Argentina	29	31	
Brazil	130	139	
Canada	571	610	705
Mexico	176	186	185
Peru	156	145	123
United States	316	343	350
Total	1 378	1 454	
Asia			
Japan	708	666	678
Korea, Rep.	126	186	
Others	148	154	
Total	982	1 006	
Oceania			
Australia	308	312	305
Total Western World	4 854	5 032	5 220

Source: International Lead and Zinc Study Group.

[1] Includes Namibia. [2] Preliminary, not available separately.

TABLE 6. WESTERN WORLD ZINC CONSUMPTION 1986-88

	1986	1987	1988[2]
	(000 tonnes)		
Europe			
Belgium	172	163	
France	260	248	
Germany, F.R.	434	452	
Italy	232	245	
Spain	100	110	
United Kingdom	182	188	
Yugoslavia	90	96	
Others	233	224	
Total	1 703	1 726	1 805
Africa			
South Africa[1]	83	84	
Others	63	63	
Total	146	147	
Oceania			
Australia	81	86	
New Zealand	18	12	
Total	99	98	
Americas			
Brazil	151	173	
Canada	154	167	
Mexico	92	110	
United States	997	1 052	1 120
Others	139	159	
Total	1 533	1 661	
Asia			
India	134	131	
Japan	753	729	776
Korea, Rep.	154	179	
Others	354	371	
Total	1 395	1 410	
Total Western World	4 876	5 041	5 283

Source: International Lead and Zinc Study Group.
[1] Includes Namibia. [2] Preliminary, not available separately.

TABLE 7. CANADA, PRIMARY ZINC METAL CAPACITY, 1988

Company and Location	Annual Rated Capacity
	(000 tonnes of slab zinc)
Canadian Electrolytic Zinc Limited (CEZ) Valleyfield, Quebec	227
Falconbridge Limited Timmins, Ontario	133
Hudson Bay Mining and Smelting Co., Limited Flin Flon, Manitoba	85
Cominco Ltd. Trail, British Columbia	272
Canada total	717

TABLE 8. MONTHLY AVERAGE ZINC PRICES (High Grade Zinc), 1987-88

	European Producer Price (US¢/lb.)	American Producer (US¢/lb.)	Canadian Producer (C¢/lb.)	LME Settlement (US¢/lb.)
1988				
January	39.7	44.4	59.0	39.9
February	40.4	45.4	59.0	39.7
March	42.4	47.9	60.8	44.2
April	45.3	51.5	65.0	48.4
May	49.0	56.0	69.2	53.4
June	55.0	62.6	76.1	62.1
July	56.1	65.6	77.5	56.1
August	54.4	66.5	77.5	59.4
September	60.9	68.3	84.5	60.3
October	63.1	69.5	85.0	68.9
November	65.8	72.0	86.5	70.6
December	68.0	75.0	89.5	72.3
Year Average	53.3	60.4	74.1	56.3
1987				
January	37.3	41.4	55.6	34.5
February	34.9	38.4	50.5	33.5
March	34.9	37.7	49.7	33.1
April	34.9	38.2	50.0	34.5
May	37.1	42.2	58.6	38.1
June	37.6	45.0	63.2	39.9
July	39.0	45.7	64.0	37.7
August	39.0	44.4	64.0	36.4
September	37.2	42.6	58.4	34.3
October	37.2	41.7	56.5	34.9
November	37.7	42.4	58.0	38.5
December	39.0	43.3	59.0	39.2
Year Average	37.2	41.9	57.3	36.2

Sources: Metals Week, ILZSG, Northern Miner.

Principal Canadian Nonferrous and Precious Metal Mine Production in 1987, with Highlights for 1988

PRINCIPAL CANADIAN NONFERROUS AND PRECIOUS METAL MINE PRODUCTION IN 1987, WITH HIGHLIGHTS FOR 1988

Company and Mine/Mill Location	Capacity	Grades of Ore Milled						Ore Milled	Metal Contained in All Concentrates Produced						1988 Highlights
		Cu	Ni	Pb	Zn	Ag	Au		Copper	Nickel	Zinc	Lead	Silver	Gold	
	(tonnes per day)	%	%	%	%	(g/tonne)		(tonnes)	(tonnes)				(kilograms)		
NEWFOUNDLAND															
Hope Brook Gold Inc. (BP Resources Canada Limited) Hope Brook mine Couteau Bay	3 000	-	-	-	-	-	4.5	-	-	-	-	-	-	-	Production began August 1987 from open-pit heap leach operation. Underground production started in 1988.
Teck-Amax Joint Venture Daniel's Harbour	1 451	-	-	-	6.63	-	-	140 456	-	-	9 135	-	-	-	Mine closed April 1986, reopened September 1987. Mine expected to close permanently in 1989 as ore reserves exhausted.
NOVA SCOTIA															
Westminer Canada Limited (Seabright Resources Inc.)*															* Amalgamated into Westminer Canada Limited in 1988. Caribou mine closed in 1988.
Forest Hill	110	-	-	-	-	-	8.4	-	-	-	-	-	-	-	
Beaver Dam	220	-	-	-	-	-	9.6	-	-	-	-	-	-	-	
NEW BRUNSWICK															
Brunswick Mining and Smelting Corporation Limited, No. 12 mine Bathurst	10 251	0.37	-	3.46	8.85	103.9	0.6	3 446 922	9 952	-	258 110	89 468	250 259	103	
East-West Minerals NL Caribou mine Bathurst	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Mine developed in the 1960s and operated sporadically until the mid-1970s. Mine reopened in 1988.
Gordex Minerals Limited Cape Spencer	635	-	-	-	-	0.1	1.47	61 748	-	-	-	-	4	64	

QUEBEC

Agnico-Eagle Mines Limited Joutel	1 633	-	-	-	-	2.4	5.69	451 897	-	-	-	-	543	2 327	
American Barrick Resources Corporation Camflo Division Val-d'Or	1 179	-	-	-	-	0.17	3.05	440 721	-	-	-	-	73	1 291	
Audrey Resources Inc. Mobrun mine Rouyn-Noranda		-	-	-	-	-	-	-	-	-	-	-	-	-	Ore milled at Minnova Inc.'s Norbec mill until Aug. 1988 when mine closed pending construction of 1 000 t/d mill by mid-1989. Shaft being deepened and mine development continuing.
Bachelor Lake Gold Mines Inc. Desmaraisville	454	-	-	-	-	0.27	4.7	28 712	-	-	-	-	7	124	
Belmoral Mines Ltd. Ferderber mine Dumont mine Val-d'Or	1 361	-	-	-	-	0.58	5.04	351 106	-	-	-	-	190	1 624	
BP Resources Canada Limited Les Mines Selbaie A-1 open pit, B and A-2 underground mines Joutel	7 013	1.15	-	-	2.21	67.54	0.41	2 352 860	26 157	-	45 349	-	47 746	895	A-2 underground mine opened late 1988. Exploration continuing to increase ore reserves.
Cambior inc. Yvan Vézina mine Rouyn	998	-	-	-	-	1.41	3.09	325 714	-	-	-	-	409	1 057	
Campbell Resources Inc./ Meston Lake Resources Inc. Joe Mann mine Chibougamau	700	0.3	-	-	-	-	6.9	-	-	-	-	-	-	-	Mine startup April 1987, ore milled at Camchib mill. Decision to sink shaft and refurbish on-site mill. Production to increase from 630 t/d to 1630 t/d in 1991.
Campbell Resources Inc. Henderson I and II, Cedar Bay and S-3 mines, common mill	3 266	0.54	-	-	-	5.52	4.83	371 154	1 946	-	-	-	1 807	2 603	Henderson II mine closed and Cedar Bay shaft deepened in 1988. Feasibility study of Devlin project under way.

Principal Canadian Nonferrous and Precious Metal Mine Production in 1987, with Highlights for 1988 (cont'd)

Company and Mine/Mill Location	Capacity	Grades of Ore Milled						Ore Milled	Metal Contained in All Concentrates Produced						1988 Highlights
		Cu	Ni	Pb	Zn	Ag	Au		Copper	Nickel	Zinc	Lead	Silver	Gold	
	(tonnes per day)	%	%	%	%	(g/tonne)		(tonnes)			(tonnes)		(kilograms)		
QUEBEC (cont'd)															
D'Or Val Mines Ltd.* Beacon mine Val d'Or	450 (mine)	-	-	-	-	-	4.4	-	-	-	-	-	-	-	* Amalgamated into Amalgamated d'Or Val Perron Mines Ltd. in 1988. 1200 t/d mill has capacity for custom feed.
Kiena Gold Mines Limited Val-d'Or	1 250	-	-	-	-	0.69	4.56	478 752	-	-	-	-	307	2 087	
Lac Minerals - SOQUEM Joint Venture Cadillac	1 361	-	-	-	-	0.72	8.47	466 810	-	-	-	-	308	3 470	Increasing mill capacity to 3 000 t/d.
Lac Minerals Ltd.															
Est-Malartic Division Malartic	1 996	-	-	-	-	0.62	5.38	698 786	-	-	-	-	399	2 891	
Terrains Aurifères Division Cadillac	1 588	-	-	-	-	1.20	5.52	531 943	-	-	-	-	584	2 692	
Louvem Mines Inc. Val-d'Or	900	-	-	-	-	0.52	6.54	1 657 767	-	-	-	-	84	963	
Minnova Inc.															
Lake Dufault Division Corbet and Ansil mines Noranda	1 542	0.99	-	-	2.2	30.03	2.26	240 668	1 855	-	4 299	-	2 074	254	Mill processed stockpiled ore from closed Corbet mine in 1987 and ore from Audrey Resources Inc. until Aug. 1988, then closed for refurbishing to process Ansil ore, beginning early 1989.
Lake Shortt Division Desmaraisville	1 089	-	-	-	-	0.21	4.59	395 748	-	-	-	-	73	1 696	
Opemiska Division Perry, Springer & Cooke mines, Chapais	2 540	1.36	-	-	-	10.29	2.13	407 229	5 401	-	-	-	3 559	719	Production to continue as long as cash flow is positive.

Muscocho Explorations Ltd. Montauban mine Montauban	399	-	-	-	-	50.67	3.31	120 967	-	-	-	-	3 349	346	
Noranda Inc.															
Division Mines Gaspé E-32 zone and Needle Mountain mine Murdochville	10 002	2.0	-	-	-	5.9	0.07	341 311	6 426	-	-	-	1 509	6	Mine to reopen early 1989 following rehabilitation after April 1987 fire. Also produces molybdenum.
Horne Division Rouyn-Noranda	3 447	-	-	-	-	4.49	4.97	24 324	-	-	-	-	103	114	
Mattagami Division Matagami	3 946	0.99	-	-	5.23	24.92	0.39	981 571	8 580	-	44 995	-	5 316	86	Isle Dieu mine opened Sept. 1988. Mattagami reserves exhausted end 1988. Production continues from Norita mine. Drilling continues to further define 2 Mt Norita East orebody.
Northgate Mines Inc. Copper Rand and [illegible]ge mines Chibougamau	3 084	1.46	-	-	-	8.67	4.66	498 338	7 125	-	-	-	2 922	2 087	Western Mining Corporation Holdings Limited purchased the company from parent Northgate Exploration Limited.
Sigma Mines (Quebec) Ltd. Val-d'Or	1 270	-	-	-	-	0.86	4.70	440 138	-	-	-	-	364	1 998	
ONTARIO															
Agnico-Eagle Mines Limited Silver Division Cobalt	260	-	-	-	-	764.57	-	25 953	-	-	-	-	18 992	-	
Ateba Mines Inc. Thunder Bay	181	-	-	-	-	0.45	7.37	1 216	-	-	-	-	-	8	
Canamax Resources Inc. Kremzar mine Wawa	350	-	-	-	-	0.51	7.3	29 564	-	-	-	-	14	197	
Dickenson Mines Limited Red Lake	907	-	-	-	-	1.37	10.17	219 666	-	-	-	-	241	1 982	
Emerald Lake Resources Inc.* Golden Rose mine Sturgeon Falls	400	-	-	-	-	-	7.2	-	-	-	-	-	-	-	Mine closed 1988. * Name change to Noramco Minin Corporation in 1988.

Principal Canadian Nonferrous and Precious Metal Mine Production in 1987, with Highlights for 1988 (cont'd)

Company and Mine/Mill Location	Capacity	Grades of Ore Milled						Ore Milled	Metal Contained in All Concentrates Produced						1988 Highlights
		Cu	Ni	Pb	Zn	Ag	Au		Copper	Nickel	Zinc	Lead	Silver	Gold	
	(tonnes per day)	%	%	%	%	(g/tonne)		(tonnes)	(tonnes)				(kilograms)		
ONTARIO (cont'd)															
Falconbridge Limited Sudbury operations (7 mines) Falconbridge and Strathcona mills	11 796	1.21	1.43	-	-	5.39	0.11	2 388 818	27 269	29 371	-	-	9 882	192	Sinking of exploration shaft commenced at Lindsley deposit. Development drilling to further define 4 Mt high grade copper orebody. Development ore graded 8% copper and 1% nickel.
Timmins operations	13 499	3.06	-	0.23	5.72	77.75	-	4 245 469	124 631	-	212 378	7 650	299 089	-	Deep drilling indicates copper and zinc mineralization to 7000 ft. level or 2000 ft. below present workings. Production of "C" ore ceased in 1988.
Kidd Creek Gold Hoyle Pond mine Owl Creek mine	408	-	-	-	-	6.0	11.38	207 584	-	-	-	-	1 143	2 168	Includes gold production at Timmins operation.
Giant Yellowknife Mines Limited															
Pamour No. 1 mill	2 631	-	-	-	-	1.51	2.47	884 873	-	-	-	-	317	1 963	
Shumacher mill	2 585	0.03	0.01	0.01	0.04	2.57	2.54	901 291	148	-	-	-	1 327	1 896	
Golden Shield Resources Ltd. Kerr Addison mine Virginiatown	1 225	-	-	-	-	0.17	3.43	343 259	-	-	-	-	57	1 147	
Hemlo Gold Mines Inc.															
Golden Giant mine Marathon	3 000	-	-	-	-	5.14	13.51	884 979	-	-	-	-	425	11 369	
INCO Limited (10 mines, Sudbury area)	56 245	1.15	1.21	-	-	5.9	0.38	10 461 316	114 152	106 005	-	-	48 211	2 491	Modernizing Clarabelle Mill as part of mill rationalization program that will result in closure of Frood-Stobie Mill and only dewatering operations at Copper Cliff Mill.
Lac Minerals Ltd.															
Hemlo Division Marathon	4 050	-	-	-	-	0.87	7.17	1 223 518	-	-	-	-	1 007	8 285	Court dispute with International Corona Resources Ltd. (this company amalgamated into Corona Corporation in 1988) not settled by end of 1988.
Macassa Division Kirkland Lake	454	-	-	-	-	2.57	15.63	145 521	-	-	-	-	355	2 134	

Lake Asbestos of Quebec, Ltd. Aquarius mill	272	-	-	-	-	3,02	6,27	66 065	-	-	-	-	185	386	
Mattabi Mines Limited Ignace	2 788	0,52	-	0,99	9,90	101,49	0,34	864 789	4 001	-	77 864	7 131	73 396	216	Mattabi mine closed Sept. 1988 when reserves exhausted. Lyon Lake mine reserves likely to be exhausted by end 1989.
Minnova Inc. Zenmac mine Winston Lake	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Zinc-copper-gold mine and 1000 t/d mill opened in 1988 to achieve full production in 1989.
Geco Division Manitouwadge	1 629	1,70	-	0,23	4,81	59,66	0,34	1 278 891	20 691	-	58 439	2 196	58 572	85	
Orofino Resources Limited Scadding Twp.	141	0,89	-	-	-	-	6,34	41 683	-	-	-	-	-	215	
Pamorex Minerals Inc. Canamax Resources Inc. Bell Creek mine Timmins	300	-	-	-	-	-	5,5	-	-	-	-	-	-	-	Canamax purchased Pamorex share of operation in 1988.
Placer Dome Inc. Campbell mine Red Lake	1 066	-	-	-	-	1,99	21,67	355 273	-	-	-	-	668	7 291	
Detour Lake mine N.E. Ontario	2 230	-	-	-	-	0,86	2,78	748 511	-	-	-	-	605	1 953	Underground mining began late 1987.
Dome mine South Porcupine	2 722	-	-	-	-	0,79	4,32	986 201	-	-	-	-	745	4 106	
Royex Gold Mining Corporation* - American Barrick Resources Corporation Renabie mine Wawa	594	-	-	-	-	1,65	6,41	200 259	-	-	-	-	255	1 190	* Amalgamated into Corona Corporation in 1988.
Teck-Corona Operation David Bell mine Marathon	998	-	-	-	-	0,55	13,23	364 730	-	-	-	-	198	4 643	
MANITOBA															
Granges Exploration Ltd. Aberdeen Corporation Tartan Lake mine Flin Flon	476	-	-	-	-	0,96	8,57	27 216	-	-	-	-	16	156	

Principal Canadian Nonferrous and Precious Metal Mine Production in 1987, with Highlights for 1988 (cont'd)

Company and Mine/Mill Location	Capacity	Grades of Ore Milled						Ore Milled	Metal Contained in All Concentrates Produced						1988 Highlights
		Cu	Ni	Pb	Zn	Ag	Au		Copper	Nickel	Zinc	Lead	Silver	Gold	
	(tonnes per day)	%	%	%	%	(g/tonne)		(tonnes)			(tonnes)		(kilograms)		
MANITOBA (cont'd)															
Hudson Bay Mining and Smelting Co., Limited (9 mines), Flin Flon & Snow Lake concentrators	10 523	2.29	-	0.06	1.83	17.85	1.53	1 866 380	40 409	-	60 206	1 065	22 035	17 921	Development under way to mine Callinan orebody in late 1989. The Chisel Lake mine will be expanded in 1989. Shaft sinking at Trout mine completed by end 1988. Development and ramping to continue through 1989. Ghost Lake, Centennial and Anderson Lake closed in 1988 as ore reserves exhausted.
Rutten mine Leaf Rapids	6 700	1.54	-	-	1.01	11.02	0.79	1 850 307	26 585	-	15 987	-	14 215	488	Ruttan mine closed by strike June 1-Sept. 8, 1988.
Hudson Bay/Outokumpu Joint Venture Namew Lake mine Flin Flon	1 900	0.90	2.44	-	-	-	-	-	-	-	-	-	-	-	Production began fall 1988.
INCO Limited Thompson underground and open pit mines Thompson district	13 608	0.19	2.76	-	-	5.14	0.10	2 432 337	4 313	61 650	-	-	9 756	152	Thompson open pit south and Birchtree mines to be developed in 1989.
LynnGold Resources Inc. MacLellan mine Flin Flon	1 089	-	-	-	-	15.98	5.45	264 236	-	-	-	-	2 004	1 270	In early 1988 Hayes Resources Inc. purchased SherrGold Inc. from Sherritt Gordon Limited then later changed the name to LynnGold Resources Inc.
Pioneer Metals Corporation Puffy Lake mine Sherridon	900	-	-	-	-	-	7.2	-	-	-	-	-	-	-	Start-up late December 1987.
SASKATCHEWAN															
Saskatchewan Mining Development Corporation (SMDC) Star Lake mine La Ronge	181	-	-	-	-	2.4	15.77	71 629	-	-	-	-	138	1 053	Star Lake ore reserves exhausted end of 1988, mill will operate until April 1989. SMDC merged with Eldorado Nuclear Limited to form Cameco - A Canadian Mining & Energy Corporation.

BRITISH COLUMBIA

Blackdome Mining Corporation Blackdome mine Williams Lake	181	-	-	-	-	74.74	21.26	74 000	-	-	-	-	3 759	1 387	
Brenda Mines Ltd. Peachland	29 937	0.19	-	-	-	1.75	0.03	10 291 394	17 728	-	-	-	8 949	133	Mine life extended from mid-1989 to mid-1990. Also produces molybdenum.
Broken Hill Proprietary Company Limited, The Utah Division Island Copper mine Port Hardy	46 502	0.42	-	-	-	1.65	0.18	17 089 030	60 864	-	-	-	13 914	1 529	Also produces molybdenum and rhenium.
Cominco Ltd. Sullivan mine Kimberley	9 072	-	-	6.30	6.05	67.2	-	1 264 303	-	-	70 040	72 770	75 424	-	17-week strike in mid-1987.
Dickenson Mines Limited Silvana Division Silmonac mine New Denver	109	-	-	9.41	5.9	612.34	-	25 653	-	-	1 434	2 340	15 244	-	
Gibraltar Mines Limited McLeese Lake	37 195	0.35	-	-	-	1.03	0.01	12 575 395	33 529	-	-	-	7 487	50	Strike May 7 to Nov. 28, 1988 closed sulfide operations but leaching and solvent extraction electrowinning production continued. Also produces molybdenum.
Highland Valley Copper (Partnership of Cominco Lornex & Highmont) Logan Lake	120 021	0.44	-	-	-	1.37	0.01	41 999 932	160 962	-	-	-	28 263	119	Moving Highmont mill to Lornex mill. Bethlehem mill will close in mid-1989 following integration of Lornex-Highmont mill in May 1989, to operate at 140 000 t/d. Also produces molybdenum.
Mascot Gold Mines Limited* Nickel Plate mine Hedley	2 449	-	-	-	-	2.23	4.04	481 454	-	-	-	-	832	1 512	* Amalgamated into Corona Corporation in 1988. Open pit started mid-1987, considering underground development.
Minnova Inc. Samatosum mine Adams Lake	-	-	-	-	-	-	-	-	-	-	-	-	-		Zinc-copper-lead-silver mine under development for production at 450 t/d by late 1989.

Principal Canadian Nonferrous and Precious Metal Mine Production in 1987, with Highlights for 1988 (cont'd)

Company and Mine/Mill Location	Capacity	Grades of Ore Milled						Ore Milled	Metal Contained in All Concentrates Produced						1988 Highlights
		Cu	Ni	Pb	Zn	Ag	Au		Copper	Nickel	Zinc	Lead	Silver	Gold	
	(tonnes per day)	%	%	%	%	(g/tonne)		(tonnes)			(tonnes)		(kilograms)		
BRITISH COLUMBIA (cont'd)															
Mosquito Consolidated Gold Mines Limited Mosquito Creek mine	100	-	-	-	-	3.98	12	4 672	-	-	-	-	17	50	
Newmont Mines Limited Similkameen Division Princeton	19 051	0.44	-	-	-	3.43	0.13	6 842 429	23 352	-	-	-	11 730	10	Purchased in July 1988 by Cassiar Mining Corporation which introduced 7-year mine plan. Newmont had planned to close mine mid-1990.
Noranda Inc. Bell Copper mine Babine Lake	15 422	0.45	-	-	-	1.3	0.17	5 409 542	21 980	-	-	-	3 545	889	Mine life extended after additional reserves proved up. Studying feasibility of mining Granisle deposit once Bell reserves exhausted late 1992.
Placer Dome Inc. Equity Silver mine Houston	9 888	0.26	-	-	-	78.89	0.85	3 610 049	6 149	-	-	-	159 959	1 273	Exploring for additional reserves under South Tail Zone and Main Zone.
Taurus Resources Ltd.* Cassiar area	163	-	-	-	-	1.44	3.74	33 981	-	-	-	-	27	70	* Name changed in 1988 to International Taurus Resources Inc.
Teck Corporation Afton Operating Corporation Kamloops	6 804	0.82	-	-	-	4.42	0.65	2 931 565	19 805	-	-	-	8 305	1 527	Comet-Davenport pit and low grade stockpile to be exhausted in early 1989. Mining to start in nearby Ajax pit in early 1989, pending permitting.
Beaverdell mine Beaverdell	101	-	-	0.42	0.48	328.11	-	36 533	-	-	153	135	10 573	-	
Total Erickson Resources Ltd. Cassiar	181	-	-	-	-	6.86	14.4	86 345	-	-	-	-	536	1 154	Closed late 1988.
Westmin Resources Limited H-W, Lynx mines Buttle Lake	3 500	2.46	-	0.36	4.91	40.11	1.99	1 089 805	25 137	-	47 579	3 374	33 197	1 320	Expansion of milling capacity to 4 000 t/d in 1988.

YUKON TERRITORY															
Canamax Resources Inc. Ketza River	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Gold mining operations b... early 1988 at 350 t/d.
Curragh Resources Corporation* Faro mine	13 500	0.15	-	3.31	4.93	39.5	0.11	4 539 394	2 975	-	184 727	121 539	109 211	1 448	Nearby Grum, DY and Vangorda deposits likely to eventually replace Faro mine. * Name changed in 1988 to 630902 Ontario Inc.
Total Erickson Resources Ltd. Mount Skukum mine	272	-	-	-	-	13.03	15.39	97 032	-	-	-	-	1 068	1 580	Closed 1988.
United Keno Hill Mines Limited Elsa, Husky, No Cash, Keno mines Elsa	454	-	-	2.32	-	781.71	-	78 834	-	-	-	1 315	48 130	-	Closed early 1989 due to low silver prices.
NORTHWEST TERRITORIES															
Cominco Ltd. Polaris mine Little Cornwallis Island	3 348	-	-	3.00	13.6	-	-	983 755	-	-	129 456	28 158	-	-	
Echo Bay Mines Ltd. Lupin mine Contwoyto Lake	1 678	-	-	-	-	1.68	10.29	612 576	-	-	-	-	906	6 006	
Giant Yellowknife Mines Limited Yellowknife Division Giant mine Yellowknife	1 134	-	-	-	-	2.06	8.16	349 841	-	-	-	-	623	2 472	
Salmita Division	159	-	-	-	-	5.14	26.23	21 155	-	-	-	-	107	565	Mine closed mid-1987.
Nanisivik Mines Ltd. Baffin Island	1 996	-	-	0.60	8.90	39.81	-	688 000	-	-	58 267	3 896	21 315	-	
NERCO Minerals Company Con and Rycon mines Yellowknife	680	-	-	-	-	1.71	13.71	198 773	-	-	-	-	316	2 492	
Pine Point Mines Limited Pine Point	9 979	-	-	3.9	9.6	-	-	3 187 847	-	-	293 626	121 471	-	-	Mine closed mid-1987. Milling continued into 1988.
CANADA	541 136	0.55	0.14	0.32	1.05	12.73	0.79	161 728 423	802 313	197 026	1 572 044	462 505	1 449 380	113 709	

- Nil.

Note: The above totals represent the metals in all of the concentrates produced, and do not represent the total metal recovered. All metallurgical treatment methods involve metal losses; further, some metals in other concentrates (eg: copper in zinc concentrates) may be sent to facilities where only the principal metal is recovered.

STATISTICAL REPORT

71.1

The statistical material contained in this summary was principally derived from surveys conducted by the Information Systems Division of the Mineral Policy Sector of Energy, Mines and Resources Canada.

The statistical survey program of Energy, Mines and Resources Canada is conducted jointly with the provincial governments and Statistics Canada. This joint program is intended to minimize the reporting burden on the mineral companies. The cooperation of the companies that provide information is greatly appreciated. Without this cooperation, a statistical report of this nature would not be possible. International mineral statistics contained in this summary are derived from the U.S. Bureau of Mines, the American Bureau of Metal Statistics, the World Bureau of Metal Statistics, "Metals Week," and the "Engineering and Mining Journal." This statistical summary of the mineral industry in Canada for the year 1988 was prepared by J. Brennan and staff, Information Systems Section, Mineral Policy Sector, Energy, Mines and Resources Canada, Ottawa. Telephone (613) 992-6439.

STATISTICAL TABLES

Table No.

Canada, general economic indicators, 1973-87.

SECTION 1. PRODUCTION

1 Mineral production of Canada, 1986-88, and average 1984-88
2 Canada, value of mineral production, per capita value of mineral production, and population, 1958-88
3 Canada, value of mineral production by provinces, territories and mineral classes, 1987
3A Canada, value of mineral production by provinces, territories and mineral classes, 1988
4 Canada, percentage contribution of leading minerals to total value of mineral production, 1982-88
5 Production of leading minerals by provinces and territories in Canada, 1986
5A Production of leading minerals by provinces and territories in Canada, 1987
5B Production of leading minerals by provinces and territories in Canada, 1988
6 Canada, value of mineral production by provinces and territories, 1982-88
7 Canada, percentage contribution of provinces and territories to total value of mineral production, 1982-88
8 Canada's world role as a producer of certain important minerals, 1986
9 Canada, census value added, total activity, mining and mineral manufacturing industries, 1980-86
10 Canada, gross domestic product of industrial production, mining and mineral manufacturing at factor cost, 1981-87
11 Canada, gross domestic product by industries at factor cost, 1981-87
12 Canada, gross domestic product for selected industries by province, 1985
13 Canada, gross domestic product for mining by province, 1979-84
14 Canada, gross domestic product for mineral manufacturing by province, 1984

SECTION 2: TRADE

15 Canada, value of mineral exports, 1981-87
16 Canada, value of mineral imports, 1981-87
17 Canada, value of mineral exports in relation to total domestic export trade, 1977, 1982 and 1987

18 Canada, value of mineral imports in relation to total import trade, 1977, 1982 and 1987.
19 Canada, value of mineral exports by main groups and destination, 1987.
20 Canada, value of mineral imports by main groups and origin, 1987.
21 Canada, value of mineral exports by commodity and destination, 1987.
22 Canada, value of mineral imports by commodity and origin, 1987.
23 Canada, physical volume of import trade for selected commodities, 1981–87.
24 Canada, physical volume of export trade for selected commodities, 1981–87.
25 Canada, major mineral export destinations by class of product, value and percentage, 1987.
26 Canada, major mineral import origins by class of product, value and percentage, 1987.

SECTION 3: CONSUMPTION

27 Canada, apparent consumption of some minerals and relation to production, 1985–87.
28 Canada, reported consumption of minerals and relation to production, 1985–87.
29 Canada, domestic consumption of principal refined metals in relation to refinery production, 1981–87.

SECTION 4: PRICES

30 Average annual prices of selected minerals, 1981–87.
31 Canadian average annual prices of selected minerals, 1981–87.
32 Canada, mineral products industries, selling price indexes, 1981–87.
33 Canada, selling price indexes of mineral raw materials, 1981–87.

SECTION 5: PRINCIPAL STATISTICS

34 Canada, principal statistics of the mineral industry, 1986.
35 Canada, principal statistics of the mineral manufacturing industries, 1986.
36 Canada, principal statistics of the mineral industry by region, 1986.
37 Canada, principal statistics of the mineral manufacturing industry by region, 1985.
38 Canada, principal statistics of the mineral industry, 1980–86.
39 Canada, principal statistics of the mineral manufacturing industries, 1980–86.
40 Canada, consumption of fuel and electricity in the mineral industry, 1986.
41 Canada, consumption of fuel and electricity in the mineral manufacturing industries, 1985.
42 Canada, cost of fuel and electricity used in the mining industry, 1980–86.
43 Canada, cost of fuel and electricity used in the mineral manufacturing industry, 1980–85

SECTION 6: EMPLOYMENT, SALARIES AND WAGES

44 Canada, employment, salaries and wages in the mining industry, 1980–86.
45 Canada, employment, salaries and wages in the mineral manufacturing industries, 1980–86.
46 Canada, number of wage earners employed in the mining industry (surface, underground and mill), 1980–86
47 Canada, mine and mill workers by sex, 1986.

Table No.

48 Canada, labour costs for metal mines in relation to tonnes mined, 1984–86
49 Canada, person–hours paid for production and related workers, and tonnes of ore mined and rock quarried in metal mines and other mineral operations, 1980–86
50 Canada, average weekly wages and hours worked (including overtime) for hourly–rated employees in mining, manufacturing and construction industries, 1981–87
51 Canada, average weekly wages (including overtime) of hourly–rated employees in the mining industry, in current and 1981 dollars, 1981–87
52 Canada, industrial fatalities per thousand workers by industry groups, 1985–87
53 Canada, rate of industrial fatalities per thousand workers by industry groups, 1981–87
54 Canada, industrial fatalities by occupational injuries and illnesses, 1985–87
55 Canada, number of strikes and lockouts by industries, 1985–87
56 Canada, number of strikes and lockouts by mining and mineral manufacturing industries, 1985–87

SECTION 7: MINING, EXPLORATION AND DRILLING

57 Canada, source of ores hoisted or removed from selected types of mines, 1984–86
58 Canada, source of material hoisted or removed from selected types of mines, 1986
59 Canada, ore mined and rock quarried in the mining industry, 1980–86
60 Canada, exploration and capital expenditures in the mining industry by provinces and territories, 1986–88
61 Canada, exploration and capital expenditures in the mining industry by type of mining, 1986–88
62 Canada, diamond drilling in the mining industry by mining companies with own equipment and by drilling contractors, 1984–86
63 Canada, ore mined and rock quarried in the mining industry, 1957–86
64 Canada, total diamond drilling, metal deposits, 1957–86
65 Canada, exploration diamond drilling, metal deposits, 1957–86
66 Canada, diamond drilling other than for exploration, metal deposits, 1957–86

SECTION 8: TRANSPORTATION

67 Canada, crude minerals transported by Canadian railways, 1984–86
68 Canada, fabricated mineral products transported by Canadian railways, 1984–86
69 Canada, crude and fabricated minerals transported by Canadian railways, 1956–86
70 Canada, crude and fabricated minerals transported through the St. Lawrence Seaway, 1985–87
71 Canada, crude and fabricated minerals transported through the St. Lawrence Seaway, 1957–87
72 Canada, crude minerals loaded and unloaded in coastwise shipping, 1987
73 Canada, fabricated minerals loaded and unloaded in coastwise shipping, 1987
74 Canada, crude and fabricated minerals loaded at Canadian ports in coastwise shipping, 1957–87
75 Canada, crude minerals loaded and unloaded at Canadian ports in international shipping trade, 1985–87
76 Canada, fabricated mineral products loaded and unloaded at Canadian ports in international shipping trade, 1985–87
77 Canada, crude and fabricated minerals loaded at Canadian ports in international shipping trade, 1957–87

SECTION 9: INVESTMENT AND FINANCE

78 Canada, financial statistics of corporations in the mining industry by degree of non-resident ownership, 1985
79 Canada, financial statistics of corporations in the mineral manufacturing industries by degree of non-resident ownership, 1985
80 Canada, financial statistics of corporations in nonfinancial industries by major industry group and by control, 1984 and 1985
81 Canada, capital and repair expenditures by selected industrial sectors, 1986–88
82 Canada, capital and repair expenditures in mining by geographical region, 1986–88
83 Canada, capital and repair expenditures in mining and mineral manufacturing industries, 1986–88
84 Canada, capital and repair expenditures in the mining industry, 1982–88
85 Canada, capital and repair expenditures in the mineral manufacturing industries, 1982–88
86 Canada, capital expenditures in the petroleum, natural gas and allied industries, 1982–88

SECTION 10: RESEARCH AND DEVELOPMENT

87 Canada, total intramural research and development expenditures for mining-related industries in current and constant (1981) dollars, 1982–88.
88 Canada, current and capital intramural research and development expenditures for mining-related industries, 1982–88

CANADA, GENERAL ECONOMIC INDICATORS, 1973–87

		1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987p
Gross domestic product, current dollars	$ million	127 372	152 111	171 540	197 924	217 879	241 604	276 069	309 891	355 994	374 750	405 425	444 735r	478 765r	506 483	549 692
Gross domestic product, constant dollars (1981 = 100)	"	264 369	276 006	283 187	300 638	311 347	325 751	338 362	343 384	355 994	344 082	354 780	377 865r	395 217r	407 736	424 136
Mining's gross domestic product (1981 = 100)	"	25 996	23 776	19 521	19 586	18 894	17 879	20 215	19 660	17 453	16 463	17 019	20 753r	21 603r	21 114	21 883
Manufacturing's gross domestic product (1981 = 100)	"	53 679	55 294	51 601	55 382	57 391	60 006	62 254	59 461	61 648	54 844	57 954	65 979r	69 593r	71 180	74 575
Industrial production's gross domestic product (1981 = 100)	"	79 588	81 135	75 171	80 223	82 920	85 799	89 491	86 880	88 675	80 910	84 982	97 194r	102 265r	103 581	108 286
Value of manufacturing industry shipments	"	66 674	82 455	88 427	98 076	109 747	129 019	152 133	165 985	190 851	183 652	200 155	229 848r	248 415r	253 911	269 866
Value of mineral production	"	8 370	11 754	13 347	15 693	18 473	20 319	26 135	31 926	32 420	33 831	38 540	43 789	44 730r	32 446	36 039
Merchandise exports	"	25 649	32 738	33 616	38 166	44 495	53 361	65 582	76 681	84 432	84 560	90 700	112 219	120 258	119 889	126 125
Merchandise imports	"	22 726	30 903	33 962	36 606	41 523	49 048	61 157	67 903	77 140	66 739	73 054	91 493	102 783	110 079	115 149
Balance of payments, current account	"	312	−1 299	−4 631	−4 096	−4 322	−4 903	−4 864	−1 130	−6 131	2 906	2 942	2 695r	−1 935r	−10 496	−10 576
Corporation profits before taxes	"	15 417	20 062	19 663	19 985	21 090	25 360	34 884	36 456	32 638	21 110	32 684	45 855r	48 772r	46 124	57 254
Business investment, current dollars	"	24 588	30 370	35 602	40 462	43 485	47 496	56 096	64 065	76 672	71 067	70 862	73 309r	81 311r	88 773	101 581
Business investment, constant dollars (1981 = 100)	"	43 482	46 555	49 418	52 453	53 587	55 638	61 399	68 103	76 672	67 088	65 972	67 635r	72 985r	77 578	86 175
Population	000s	22 043	22 364	22 697	22 993	23 258	23 476	23 671	23 936	24 342	24 634	24 886	25 124	25 360	25 353	25 625
Labour force	"	9 276	9 639	9 974	10 203	10 500	10 895	11 231	11 573	11 904	11 958	12 183	12 399	12 639	12 870	13 121
Employed	"	8 761	9 125	9 284	9 477	9 651	9 987	10 395	10 708	11 006	10 644	10 734	11 000	11 311	11 634	11 955
Unemployed	"	515	514	690	726	849	908	836	865	898	1 314	1 448	1 399	1 328	1 236	1 167
Unemployment rate	percent	5.5	5.3	6.9	7.1	8.1	8.3	7.4	7.5	7.5	11.0	11.9	11.3	10.5	9.6	8.9
Labour income	$ million	68 423	81 656	95 277	110 419	122 476	133 383	150 172	169 736	196 002	209 449	219 352	236 204r	254 751r	271 026	288 987
Consumer price index	1981 = 100	47.6	52.8	58.5	62.9	67.9	73.9	80.7	88.9	100.0	110.8	117.2	122.4r	127.3r	132.7	129.6

p Preliminary; r Revised

TABLE 1. MINERAL PRODUCTION OF CANADA, 1986–88 AND AVERAGE 1984–88

	Unit of Measure	1986		1987		1988p		Average 1984-88	
		(Quantity)	($000)	(Quantity)	($000)	(Quantity)	($000)	(Quantity)	($000)
Metals									
Antimony	t	3 805	12 332	3 706	9 698	2 977	8 411	2 424	8 016
Bismuth	t	153	1 413	165	1 754	195	3 016	176	2 418
Cadmium	t	1 484	5 673	1 481	8 609	1 742	2 813	1 606	12 219
Calcium	t	(2)	(1)	(2)	(1)	(2)	(1)	476	4 816
Cesium, pollucite	t	(2)	(1)	(2)	(1)	(2)	(1)	122	433
Cobalt	t	2 297	46 623	2 490	46 654	2 764	52 502	2 348	55 773
Copper	000 t	699	1 426 393	794	1 923 080	722	2 317 018	735	1 699 824
Gold	kg	102 899	1 689 292	115 818	2 204 472	127 843	2 215 128	103 513	1 716 166
Ilmenite	000 t	(2)	(1)	(2)	(1)	(2)	(1)	479	17 683
Indium	kg	(2)	(1)	(2)	(1)	(2)	(1)	5 146	1 134
Iron ore	000 t	36 167	1 342 666	37 702	1 395 620	38 742	1 388 129	38 408	1 414 204
Iron remelt	000 t	(2)	(1)	(2)	(1)	(2)	(1)	640	161 155
Lead	000 t	334	227 653	373	394 817	334	333 707	315	261 263
Lithium, lepidolite, spodumene	t	(2)	(1)	(2)	(1)	(2)	(1)	573	2 492
Magnesium	t	(2)	(1)	(2)	(1)	(2)	(1)	8 370	37 112
Molybdenum	t	11 251	90 111	14 771	126 315	12 388	107 737	11 564	100 936
Nickel	000 t	164	979 100	189	1 273 043	214	3 255 974	182	1 578 329
Niobium (Nb_2O_5)	t	(2)	(1)	(2)	(1)	(2)	(1)	3 035	19 382
Platinum group	kg	12 190	(1)	10 930	181 849	11 458	171 917	11 096	164 472
Rhenium	kg	(2)	(1)	(2)	(1)	(2)	(1)	1 117	788
Rubidium	kg	(2)	(1)	(2)	(1)	(2)	(1)	1 662	22
Selenium	t	353	6 059	430	8 152	468	12 904	415	9 375
Silver	t	1 088	275 011	1 375	424 064	1 527	378 136	1 303	374 584
Strontium	t	(2)	(1)	(2)	(1)	(2)	(1)	63	1 700
Tantalum (Ta_2O_5)	t	39	3 470	36	2 364	13	1 308	25	2 037
Tellurium	t	20	706	13	411	23	876	19	630
Tin	t	(2)	(3)	(2)	(1)	(2)	(1)	1 970	18 456
Tungsten (WO_3)	t	2 470	(1)	(2)	(1)	(2)	(1)	2 139	18 691
Uranium (U)	t	11 502	1 042 334	13 612	1 182 209	13 233	1 107 956	11 812	1 047 240
Yttrium (Y_2O_3)	t	(2)	(1)	(2)	(1)	(2)	(1)	24	927
Zinc	000 t	988	1 200 630	1 158	1 475 211	1 254	2 064 647	1 102	1 510 302
Total metals			8 797 705		10 962 122		13 790 037		10 185 930

TABLE 1. (cont'd)

	Unit of Measure	1986		1987		1988^p		Average 1984-88	
		(Quantity)	($000)	(Quantity)	($000)	(Quantity)	($000)	(Quantity)	($000)
Nonmetals									
Arsenious trioxide	t	(2)	(1)	(2)	732	(2)	2 168	4	1 310
Asbestos	000 t	662	234 053	665	237 990	705	268 357	724	283 654
Barite	000 t	40	4 215	42	4 115	54	4 336	54	5 029
Fluorspar	t	(2)	(3)	(2)	(1)	(2)	(1)	13 552	1 811
Gemstone	t	354	1 287	309	1 622	440	2 098	294	1 390
Graphite	t	(2)	(1)	(2)	(1)	(2)	(1)	1 501	1 086
Gypsum	000 t	8 803	83 072	9 094	86 984	8 522	87 674	8 391	78 091
Magnesitic dolomite and brucite	000 t	(2)	(1)	(2)	(1)	(2)	(1)	146	17 736
Marl	000 t	(2)	(1)	(2)	(1)	(2)	(1)	7	111
Mica	000 t	(2)	(1)	(2)	(1)	(2)	(1)	12	4 174
Nepheline syenite	000 t	467	18 922	506	20 664	542	23 411	501	19 752
Peat	000 t	738	80 152	648	73 996	708	70 562	656	68 060
Perlite	t	(2)	(1)	(2)	(1)	(2)	(1)	880	64
Potash (K_2O)	000 t	6 753	584 304	7 668	745 009	8 070	1 058 716	7 336	777 023
Potassium sulphate	000 t	(2)	(1)	(2)	(1)	(2)	(1)	404	170
Pumice	t	(2)	(3)	(2)	(1)	(2)	(1)	260	6
Quartz	000 t	2 640	41 640	2 662	44 317	2 710	46 997	2 668	43 267
Salt	000 t	10 332	239 466	10 129	238 626	10 975	257 518	10 351	232 232
Serpentine	t	(2)	(1)	(2)	(1)	(2)	(1)	4 632	588
Soapstone, talc and									14 058
pyrophyllite	000 t	123	14 182	136	14 307	150	17 294	132	345
Sodium antimonate	t	(2)	(1)	(2)	(1)	(2)	(1)	667	30 830
Sodium sulphate	000 t	371	33 012	342	26 545	310	23 020	356	75 182
Sulphur in smelter gas	000 t	758	72 614	723	80 138	820	73 615	794	695 327
Sulphur, elemental	000 t	6 966	857 584	5 809	522 907	5 915	460 800	7 029	219 583
Titanium dioxide	000 t	(2)	(1)	(2)	(1)	(2)	(1)	671	29
Tremolite	t	(2)	(1)	(2)	(1)	(2)	(1)	182	170
Total nonmetals			2 522 182		2 379 270		2 678 080		2 535 904
Fuels									
Coal	000 t	57 811	1 725 888^r	61 211	1 641 300	69 500	1 907 800	61 272	1 782 949^r
Natural gas	million m^3	71 896	5 623 142	78 267	4 615 057	87 893	4 973 307	80 133	6 240 019
Natural gas by-products	000 m^3	19 127	1 802 454	21 560	1 876 299	22 332	1 609 518	20 468	2 189 574
Petroleum, crude	000 m^3	85 468	9 611 843	89 140	12 141 043	92 856	9 349 519	87 342	13 466 825
Total fuels			18 763 327^r		20 273 699		17 840 144		23 679 367^r

Structural materials									
Clay products	000 $	..	179 515	..	210 756	..	185 273	..	170 1[illegible]
Cement	000 t	10 611	824 344	12 603	997 227	12 611	1 012 625	11 052	867 96[illegible]
Lime	000 t	2 243	171 359	2 330	167 566	2 535	189 946	2 314	173 779
Sand and gravel	000 t	257 677	677 250	278 546	768 755	276 064	782 675	260 446	676 929
Stone	000 t	97 602	488 655	113 291	582 950	112 422	601 312	98 340	494 590
Total structural materials			2 341 123		2 727 254		2 771 831		2 383 382r
Other minerals			21 615		-		-		92 827r
Total all minerals			32 445 952r		36 342 345		37 080 092		38 877 409r

(1) Confidential – included in sub-total. (2) Production excluded due to confidentiality. (3) Value of production included under the heading "other minerals."

p Preliminary; r Revised; .. Not available; – Nil.

Note: Totals may not add due to rounding.

TABLE 2. CANADA, VALUE OF MINERAL PRODUCTION, PER CAPITA VALUE OF MINERAL PRODUCTION, AND POPULATION, 1958–88

	Metallics	Industrial Minerals	Fuels	Other Minerals[1]	Total	Per Capita Value of Mineral Production	Population of Canada
			($ million)			($)	(000)
1958	1 130	460	511		2 101	123.01	17 080
1959	1 371	503	535		2 409	137.79	17 483
1960	1 407	520	566		2 493	139.48	17 870
1961	1 387	542	674		2 603	142.72	18 238
1962	1 496	574	811		2 881	155.05	18 583
1963	1 510	632	885		3 027	159.91	18 931
1964	1 702	690	973		3 365	174.44	19 291
1965	1 908	761	1 046		3 715	189.11	19 644
1966	1 985	844	1 152		3 981	198.88	20 015
1967	2 285	861	1 235		4 381	214.98	20 378
1968	2 493	886	1 343		4 722	228.12	20 701
1969	2 378	893	1 465		4 736	225.51	21 001
1970	3 073	931	1 718		5 722	268.68	21 297
1971	2 940	1 008	2 015		5 963	276.46	21 568
1972	2 956	1 085	2 367		6 408	293.92	21 802
1973	3 850	1 293	3 227		8 370	379.69	22 043
1974	4 821	1 731	5 202		11 753	525.55	22 364
1975	4 796	1 898	6 653		13 347	588.05	22 697
1976	5 315	2 269	8 109		15 693	682.51	22 993
1977	5 988	2 612	9 873		18 473	794.24	23 258
1978	5 698	2 986	11 578		20 261	863.05^{r}	23 476
1979	7 951	3 514	14 617		26 081	1 101.83^{r}	23 671
1980	9 697	4 201	17 944		31 842	1 330.29^{r}	23 936
1981	8 753	4 485	19 046	136	32 420	1 331.86	24 342
1982	6 874	3 703	23 038	216	33 831	1 373.37	24 634
1983	7 399	3 741	27 154	245	38 539	1 548.68	24 885
1984	8 670	4 318	30 399	401	43 789	1 742.92	25 124
1985	8 709	4 859	31 120	41	44 730	1 763.79	25 360
1986	8 798	4 863	18 763^{r}	22	32 446^{r}	1 279.77^{r}	25 353^{r}
1987	10 962	5 107	20 274	–	36 342	1 418.23	25 625
1988^{p}	13 790	5 450	17 840	–	37 080	1 434.02	25 858

---

[1] 1978–86 – Other minerals may include arsenious trioxide, bentonite, calcium, cesium, cobalt, diatomite, ilmenite, indium, iron remelt, lithium, marl, magnesium, niobium, perlite, rhenium, serpentine, sodium antimonate, strontium, tin, tungsten or yttrium for which the value of production may be confidential in that year. Beginning 1987 this category was discontinued.

^{p} Preliminary; ^{r} Revised; – nil.

Notes: Beginning 1986 bentonite, diatomite and sodium antimonate are reported in industrial minerals.
Totals may not add due to rounding.

TABLE 3. CANADA, VALUE OF MINERAL PRODUCTION BY PROVINCES, TERRITORIES AND MINERAL CLASSES, 1987

	Metals		Industrial minerals		Fuels		Total	
	($000)	(% of total)	($000)	(% of total)	($000)	(% of total)	($000)	(% of total)
Alberta	825	. . .	808 455	15.8	16 270 690	80.3	17 079 970	47.0
Ontario	4 086 013	37.3	1 468 886	28.8	81 185	0.4	5 636 085	15.5
British Columbia	1 557 322	14.2	390 549	7.6	1 666 092	8.2	3 613 963	9.9
Saskatchewan	629 398	5.7	743 287	14.6	1 778 146	8.8	3 150 831	8.7
Quebec	1 694 616	15.5	1 086 143	21.3	–	–	2 780 759	7.7
Manitoba	759 341	6.9	131 218	2.6	109 486	0.5	1 000 046	2.8
Northwest Territories	696 258	6.4	17 197	0.3	155 809	0.8	869 264	2.4
Newfoundland	677 355	6.2	65 463	1.3	–	–	742 818	2.0
New Brunswick	391 836	3.6	197 048	3.9	33 347	0.2	622 231	1.7
Yukon	434 862	4.0	2 338	. . .	–	–	437 199	1.2
Nova Scotia	34 296	0.3	193 399	3.8	178 944	0.9	406 639	1.1
Prince Edward Island	–	–	2 541	. . .	–	–	2 541	. . .
Total	10 962 122	100.0	5 106 524	100.0	20 273 699	100.0	36 342 345	100.0

– Nil; . . . Amount too small to be expressed.
Note: Totals may not add due to rounding.

TABLE 3a. CANADA, VALUE OF MINERAL PRODUCTION BY PROVINCES, TERRITORIES AND MINERAL CLASSES, 1988p

	Metals		Industrial minerals		Fuels		Total	
	($000)	(% of total)	($000)	(% of total)	($000)	(% of total)	($000)	(% of total)
Alberta	354	. . .	751 611	13.8	14 154 430	79.3	14 906 395	40.2
Ontario	5 543 442	40.2	1 525 823	28.0	85 118	0.5	7 154 383	19.3
British Columbia	1 875 580	13.6	432 896	7.9	1 683 672	9.4	3 992 149	10.8
Saskatchewan	631 921	4.6	992 112	18.2	1 421 468	8.0	3 045 501	8.2
Quebec	1 661 025	12.0	1 055 127	19.4	–	–	2 716 152	7.3
Manitoba	1 472 018	10.7	124 861	2.3	83 598	0.5	1 680 477	4.5
Northwest Territories	753 866	5.5	12 289	0.2	170 131	1.0	936 286	2.5
Newfoundland	811 396	5.9	77 079	1.4	–	–	888 476	2.4
New Brunswick	545 957	4.0	251 191	4.6	33 907	0.2	831 055	2.2
Yukon	454 630	3.3	10 900	0.2	–	–	465 530	1.3
Nova Scotia	39 848	0.3	213 396	3.9	207 820	1.2	461 063	1.2
Prince Edward Island	–	–	2 625	. . .	–	–	2 625	. . .
Total	13 790 037	100.0	5 449 911	100.0	17 840 144	100.0	37 080 092	100.0

p Preliminary; – Nil; . . . Amount too small to be expressed.
Note: Totals may not add due to rounding.

TABLE 4. CANADA, PERCENTAGE CONTRIBUTION OF LEADING MINERALS TO TOTAL VALUE OF MINERAL PRODUCTION, 1982–88

	1982	1983	1984	1985	1986	1987	1988^p
Petroleum, crude	36.0	41.8	40.6	41.2	29.6	33.4	25.2
Natural gas	21.5	18.4	18.1	18.0	17.3	12.7	13.4
Nickel	1.8	2.0	2.7	2.7	3.0	3.5	8.8
Copper	3.5	3.5	3.1	3.3	4.4	5.3	6.2
Gold	2.9	3.2	2.9	2.7	5.2	6.1	6.0
Zinc	3.1	2.9	3.4	2.9	3.7	4.1	5.6
Coal	3.8	3.4	4.1	4.1	5.3	4.5	5.1
Natural gas by-products	6.8	7.0	6.5	6.3	5.6	5.2	4.3
Iron ore	3.6	3.3	3.4	3.3	4.1	3.8	3.7
Uranium (U)	2.5	1.7	2.1	2.2	3.2	3.3	3.0
Potash (K_2O)	1.9	1.7	2.0	1.4	1.8	2.0	2.9
Cement	2.0	1.6	1.6	1.8	2.5	2.7	2.7
Sand and gravel	1.6	1.6	1.2	1.4	2.1	2.1	2.1
Stone	0.8	0.8	0.9	0.9	1.5	1.6	1.6
Sulphur, elemental	1.7	1.1	1.4	2.3	2.6	1.4	1.2
Silver	1.2	1.4	1.1	0.7	0.8	1.2	1.0
Lead	0.6	0.4	0.4	0.3	0.7	1.1	0.9
Asbestos	1.1	1.0	0.9	0.7	0.7	0.7	0.7
Salt	0.5	0.4	0.5	0.5	0.7	0.7	0.7
Lime	0.4	0.4	0.4	0.4	0.5	0.5	0.5
Clay products	0.3	0.3	0.3	0.3	0.6	0.6	0.5
Platinum group	0.2	0.2	0.3	0.3	0.6	0.5	0.5
Molybdenum	0.5	0.2	0.2	0.2	0.3	0.2	0.3
Gypsum	0.1	0.2	0.1	0.2	0.3	0.2	0.2
Sulphur in smelter gas	0.1	0.1	0.1	0.2	0.2	0.3	0.2
Other minerals	1.5	1.4^r	1.7^r	1.7^r	2.7^r	2.3	2.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

^{p} Preliminary; ^{r} Revised.
Note: Totals may not add due to rounding.

TABLE 5. PRODUCTION OF LEADING MINERALS, BY PROVINCES AND TERRITORIES IN CANADA, 1986

	Unit of Measure	Nfld.	P.E.I.	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Saskatchewan	Alberta	British Columbia	Yukon	N.W.T.	Total Canada
Petroleum, crude	000 m³	–	–	–	...	–	136	823	11 688	69 322	2 021	–	1 478	85 468
	$000	–	–	–	13	–	17 303	95 337	1 172 413	7 978 155	245 326	–	103 296	9 611 843
Natural gas	million m³	–	–	–	1	–	504	–	1 814	62 556	6 820	–	201	71 896
	$000	–	–	–	14	–	65 102	–	129 792	5 048 927	366 213	–	13 094	5 623 142
Natural gas by-products	000 m³	–	–	–	–	–	–	6	205	18 402	465	–	49	19 127
	$000	–	–	–	–	–	–	503	18 184	1 743 605	36 717	–	3 445	1 802 454
Coal	000 t	–	–	2 955	485	–	–	–	8 280	24 950	21 141	–	–	57 811
	$000	–	–	177 940	28 000	–	–	–	100 602	445 579	973 767	–	–	1 725 888
Gold	kg	–	–	–	374	28 342	46 279	2 556	14	36	9 249	3 547	12 503	102 899
	$000	–	–	–	6 134	465 286	759 755	41 954	228	594	151 837	58 237	205 266	1 689 292
Copper	000 t	–	–	–	6	52	265	65	4	–	307	...	...	699
	$000	–	–	–	12 860	105 412	540 865	133 483	7 160	–	626 598	13	1	1 426 393
Iron ore	000 t	19 184	–	–	–	13 471	3 461	–	–	–	51	–	–	36 167
	$000	761 328	–	–	–	x	x	–	–	–	2 217	–	–	1 342 666
Zinc	000 t	6	–	–	162	37	265	61	4	–	138	51	265	988
	$000	6 940	–	–	196 595	45 108	322 276	74 677	4 286	–	167 163	61 521	322 064	1 200 630
Uranium (U)	000 t	–	–	–	–	–	5	–	7	–	–	–	–	12
	$000	–	–	–	–	–	566 134	–	476 200	–	–	–	–	1 042 334
Nickel	000 t	–	–	–	–	–	122	42	–	–	–	–	–	164
	$000	–	–	–	–	–	731 440	247 660	–	–	–	–	–	979 101
Sulphur, elemental	000 t	–	–	–	–	–	...	1	12	6 657	295	–	–	6 966
	$000	–	–	–	–	–	41	176	1 484	803 995	51 889	–	–	857 584
Cement	000 t	x	–	x	x	3 249	4 437	415	x	949	1 071	–	–	10 611
	$000	8 530	–	25 430	9 526	190 289	343 086	43 733	16 684	113 371	73 696	–	–	824 344
Sand and gravel	000 t	2 343	501	7 889	8 982^{r}	29 607	87 666^{r}	13 050	14 189	45 149^{r}	42 413^{r}	4 902	985	257 677^{r}
	$000	11 112	1 754	22 064	x	x	248 234^{r}	35 752	31 509	133 199^{r}	103 812^{r}	13 355	3 281	677 250^{r}
Potash (K_2O)	000 t	–	–	–	x	–	–	–	x	–	–	–	–	6 753
	$000	–	–	–	x	–	–	–	x	–	–	–	–	584 304
Stone	000 t	476	–	4 023	2 344	36 066	45 477	4 099	–	229	4 403	116	368	97 602
	$000	2 712	–	21 944	13 064	172 194	226 130	26 831	–	1 315	23 049	405	1 011	488 655
Silver	t	–	–	–	163	62	348	37	3	...	380	73	22	1 088
	$000	–	–	–	41 168	15 730	87 869	9 458	795	1	96 044	18 468	5 479	275 011
Salt	000 t	–	–	x	x	x	6 240	–	473	1 301	–	–	–	10 332
	$000	–	–	x	x	x	147 523	–	25 759	14 216	–	–	–	239 466
Asbestos	000 t	43	–	–	–	541	–	–	–	–	78	–	–	662
	$000	16 354	–	–	–	178 036	–	–	–	–	39 663	–	–	234 053
Lead	000 t	–	–	–	67	–	6	1	–	–	92	35	134	334
	$000	–	–	–	45 341	–	4 281	402	–	–	62 607	23 893	91 129	227 654
Clay products	$000	1 273	–	7 616	3 026	29 621	109 998	3 470	5 700	10 158	8 652	–	–	179 515
Lime	000 t	–	–	–	x	x	1 511	x	–	193	123	–	–	2 243
	$000	–	–	–	x	x	111 567	5 540	–	16 196	10 339	–	–	171 359
Molybdenum	t	–	–	–	–	355	–	–	–	–	10 896	–	–	11 251
	$000	–	–	–	–	2 389	–	–	–	–	87 722	–	–	90 111
Gypsum	t	486	–	6 264	–	–	1 321	247	–	–	485	–	–	8 803
	$000	6 038	–	50 126	–	–	16 974	5 039	–	–	4 896	–	–	83 072
Peat	t	2	–	x	228	334	x	x	x	72	x	–	–	738
	$000	149	–	x	21 351	30 059	x	x	x	13 930	x	–	–	80 152
Sulphur in smelter gas	000 t	–	–	–	84	42	463	1	–	...	20	...	147	758
	$000	–	–	–	8 956	7 492	31 200	211	–	13	2 953	1	21 788	72 614
Total leading minerals	$000	814 434	1 754	305 120[1]	386 049[1]	1 241 618[1]	4 329 777[1]	724 226[1]	1 990 794[1]^{r}	16 323 254^{r}	3 135 161[1]	175 893	769 854	31 528 886^{r}
Total all minerals	$000	817 338	1 754	366 719	501 574	2 190 541	4 824 739	763 892	2 524 553^{r}	16 330 583	3 159 871	176 101	788 287	32 445 952^{r}
Leading minerals as % of all minerals		99.6	100.0	83.2[2]	77.0[2]	56.7[2]	89.7[2]	94.8[2]	78.9[2]^{r}	100.0	99.2[2]	99.9	97.7	97.2

---

[1] The values of iron ore, lime, peat, potash, salt, sand and gravel are excluded as they are confidential [2] Percentages exclude those values which are confidential.

^{p} Preliminary; ^{r} Revised; – Nil; ... Amount too small to be expressed; x Confidential

Note: Totals may not add due to rounding

TABLE 5A. PRODUCTION OF LEADING MINERALS, BY PROVINCES AND TERRITORIES IN CANADA, 1987

	Unit of Measure	Nfld	P E I	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Saskat-chewan	Alberta	British Columbia	Yukon	N W T	Total Canada
Petroleum, crude	000 m³	–	–	4	...	–	136	782	12 078	72 460	2 110	–	1 570	89 140
	$000	–	–	324	13	–	19 245	109 142	1 511 466	10 050 323	306 009	–	144 521	12 141 043
Natural gas	000 m³	–	–	–	1	–	508	–	2 428	67 029	8 135	–	166	78 267
	$000	–	–	–	14	–	61 940	–	156 750	4 021 746	366 062	–	8 545	4 615 057
Gold	kg	x	–	x	420	29 543	52 917	3 697	1 048	43	11 224	4 674	11 740	115 818
	$000	7 092	–	2 640	7 986	562 327	1 007 225	70 364	19 956	824	213 632	88 970	223 456	2 204 472
Copper	000 t	–	–	x	7	67	287	66	2	–	364	x	...	794
	$000	–	–	x	17 515	161 877	695 844	160 115	5 654	–	881 772	x	4	1 923 080
Natural gas by-products	000 m³	–	–	–	–	–	–	4	214	20 752	560	–	30	21 560
	$000	–	–	–	–	–	–	344	18 080	1 808 971	46 161	–	2 743	1 876 299
Coal	000 t	–	–	2 930	533	–	–	–	10 020	25 738	21 990	–	–	61 211
	$000	–	–	178 620	33 320	–	–	–	91 850	389 650	947 860	–	–	1 641 300
Zinc	000 t	8	–	–	180	91	294	64	2	–	114	147	258	1 158
	$000	9 737	–	–	229 699	116 111	374 950	80 964	2 247	–	145 385	187 336	328 781	1 475 211
Iron ore	000 t	18 423	–	–	–	15 988	3 229	–	–	–	61	–	–	37 702
	$000	660 526	–	–	–	x	x	–	–	–	2 221	–	–	1 395 620
Nickel	000 t	–	–	–	–	–	130	59	–	–	–	–	–	189
	$000	–	–	–	–	–	869 315	403 727	–	–	–	–	–	1 273 043
Uranium (U)	000 t	–	–	–	–	–	5	–	9	–	–	–	–	14
	$000	–	–	–	–	–	581 294	–	600 915	–	–	–	–	1 182 209
Cement	000 t	x	–	x	x	3 616	5 512	x	x	1 107	1 308	–	–	12 603
	$000	9 722	–	46 464	3 451	229 987	437 808	46 755	17 735	116 947	88 358	–	–	997 227
Sand and gravel	000 t	3 319	673	8 334	11 056	36 460	96 251	14 687	11 922	44 050	49 260	352	2 183	278 546
	$000	16 451	2 541	24 368	x	x	280 725	39 264	33 619	137 523	131 316	1 502	8 132	768 755
Potash (K_2O)	000 t	–	–	–	x	–	–	–	x	–	–	–	–	7 668
	$000	–	–	–	x	–	–	–	x	–	–	–	–	745 009
Stone	000 t	931	–	4 437	2 878	42 731	52 412	3 760	2	249	5 213	206	472	113 291
	$000	8 535	–	23 133	15 934	213 112	273 032	15 959	4	1 532	29 544	679	1 486	582 950
Sulphur, elemental	000 t	–	–	–	–	–		1	12	5 471	324	–	–	5 809
	$000	–	–	–	–	–	42	194	1 470	479 370	41 831	–	–	522 907
Silver	t	–	–		182	163	441	41	2		401	133	13	1 375
	$000	–	–	54	56 176	50 148	135 958	12 643	543	1	123 569	40 965	4 006	424 064
Lead	000 t	–	–	x	66	–	6	x	–	–	57	x	132	373
	$000	–	–	x	70 333	–	6 444	x	–	–	60 382	x	139 370	394 817
Salt	000 t	–	–	x	x	x	5 690	–	460	1 191	–	–	–	10 129
	$000	–	–	x	x	x	139 326	–	26 177	17 385	–	–	–	238 626
Asbestos	000 t	62	–	–	–	505	–	–	–	–	98	–	–	665
	$000	19 191	–	–	–	171 860	–	–	–	–	46 938	–	–	237 990
Clay products	$000	1 132	–	7 584	2 935	36 125	131 568	2 958	5 633	14 183	8 639	–	–	210 756
Platinum group	kg	–	–	–	–	–	x	x	–	–	–	–	–	10 930
	$000	–	–	–	–	–	x	x	–	–	–	–	–	181 849
Lime	000 t	–	–	–	x	x	1 538	x	–	213	120	–	–	2 330
	$000	–	–	–	x	x	100 540	8 118	–	19 194	9 954	–	–	167 566
Molybdenum	t	–	–	–	–	–	–	–	–	–	14 771	–	–	14 771
	$000	–	–	–	–	–	–	–	–	–	126 315	–	–	126 315
Gypsum	000 t	x	–	6 274	x	–	1 468	380	–	–	536	–	–	9 094
	$000	5 338	–	53 479	32	–	16 547	6 060	–	–	5 529	–	–	86 984
Sulphur in smelter gas	000 t	–	–		91	37	476	–	–	–	60	1	59	723
	$000	–	–	26	13 975	7 291	44 737	–	–	–	7 041	156	6 912	80 138
Total leading minerals	$000	737 724	2 541	336 692[1]	451 382[1]	1 548 838[1]	5 176 541[1]	956 608[1]	2 492 099[1]	17 057 648	3 588 518	319 608[1]	867 956	35 493 286
Total all minerals	$000	742 818	2 541	406 639	622 231	2 780 759	5 636 085	1 000 046	3 150 831	17 079 970	3 613 963	437 199	869 264	36 342 345
Leading minerals as % of all minerals		99.3	100.0	82.8[2]	72.5[2]	55.7[2]	91.8[2]	95.7[2]	79.1[2]	99.9	99.3	73.1[2]	99.8	97.7

---

[1] The values of copper, iron ore, lead, lime, platinum group, potash, salt, and sand and gravel are excluded as they are confidential [2] Percentages exclude those values which are confidential

– Nil; Amount too small to be expressed; x Confidential

Note: Totals may not add due to rounding

TABLE 5B. PRODUCTION OF LEADING MINERALS, BY PROVINCES AND TERRITORIES IN CANADA, 1988^{p}

	Unit of Measure	Nfld.	P.E.I.	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Saskat-chewan	Alberta	British Columbia	Yukon	N.W.T.	Total Canada
Petroleum, crude	000 m^3	–	–	–		–	190	771	11 949	76 276	1 889	–	1 781	92 856
	$000	–	–	–	13	–	21 485	83 125	1 131 561	7 724 165	226 573	–	162 597	9 349 519
Natural gas	000 m^3	–	–	–	1	–	497	–	2 868	76 308	8 081	–	138	87 893
	$000	–	–	–	14	–	63 633	–	163 849	4 415 169	324 359	–	6 283	4 973 307
Nickel	000 t	–	–	–	–	–	142	72	–	–	–	–	–	214
	$000	–	–	–	–	–	2 166 259	1 089 714	–	–	–	–	–	3 255 974
Copper	000 t	–	–	x	10	45	257	53	3	–	353	x	x	722
	$000	–	–	x	30 847	145 108	824 034	171 160	8 057	–	1 134 787	x	x	2 317 018
Gold	kg	x	–	x	74	32 485	57 882	4 285	2 083	20	13 036	4 304	11 422	127 843
	$000	x	–	x	1 274	562 868	1 002 920	74 246	36 096	353	225 877	74 568	197 906	2 215 128
Zinc	000 t	30	–	x	230	73	333	57	x	–	120	118	290	1 254
	$000	49 256	–	x	379 016	120 956	548 838	94 179	x	–	196 853	194 881	477 630	2 064 647
Coal	000 t	–	–	3 425	545	–	–	–	12 025	29 270	24 235	–	–	69 500
	$000	–	–	207 820	33 880	–	–	–	110 100	456 000	1 100 000	–	–	1 907 800
Natural gas	000 m^3	–	–	–	–	–	–	6	242	21 489	581	–	14	22 332
by-products	$000	–	–	–	–	–	–	473	15 958	1 559 096	32 740	–	1 251	1 609 518
Iron ore	000 t	20 044	–	–	–	15 700	2 927	–	–	–	71	–	–	38 742
	$000	726 574	–	–	–	x	x	–	–	–	3 170	–	–	1 388 129
Uranium (U)	000 t	–	–	–	–	–	5	–	9	–	–	–	–	13
	$000	–	–	–	–	–	523 430	–	584 526	–	–	–	–	1 107 956
Potash (K_2O)	000 t	–	–	–	x	–	–	–	x	–	–	–	–	8 070
	$000	–	–	–	x	–	–	–	x	–	–	–	–	1 058 716
Cement	000 t	x	–	x	x	3 394	5 441	x	x	1 153	1 512	–	–	12 611
	$000	10 791	–	58 232	4 058	194 850	449 025	46 217	16 774	126 545	106 133	–	–	1 012 625
Sand and gravel	000 t	3 440	700	9 600	10 300	33 089	99 650	13 300	10 500	42 500	49 300	1 550	2 135	276 064
	$000	16 856	2 625	33 600	x	x	288 985	37 240	30 975	133 875	133 110	7 130	7 900	782 675
Stone	000 t	990	–	4 450	2 960	43 007	51 000	3 500	2	300	4 913	800	500	112 422
	$000	9 158	–	22 695	16 280	217 762	280 500	14 000	4	2 100	34 388	2 800	1 625	601 312
Sulphur, elemental	000 t	–	–	–	–	–	–	–	15	5 573	326	–	–	5 915
	$000	–	–	–	–	–	–	–	1 482	420 582	38 737	–	–	460 800
Silver	t	x	–	x	202	122	386	28	x	..	420	340	27	1 527
	$000	x	–	x	49 896	30 250	95 583	6 933	x	1	104 003	84 192	6 785	378 136
Lead	000 t	–	–	x	73	–	2	x	–	–	90	x	67	334
	$000	–	–	x	73 289	–	2 268	x	–	–	90 086	x	67 227	333 707
Asbestos	000 t	72	–	–	–	533	–	–	–	–	100	–	–	705
	$000	27 072	–	–	–	190 285	–	–	–	–	51 000	–	–	268 357
Salt	000 t	–	–	x	x	x	6 863	–	400	1 218	–	–	–	10 975
	$000	–	–	x	x	x	158 440	–	24 458	17 504	–	–	–	257 518
Lime	000 t	–	–	–	x	x	1 660	x	–	186	171	–	–	2 535
	$000	–	–	–	x	x	114 374	8 613	–	17 642	14 928	–	–	189 946
Clay products	$000	1 225	–	7 435	2 975	24 745	122 203	2 278	5 530	9 382	9 500	–	–	185 273
Platinum group	kg	–	–	–	–	–	x	x	–	–	–	–	–	11 458
	$000	–	–	–	–	–	x	x	–	–	–	–	–	171 917
Sulphur in smelter	000 t	–	–	1	94	23	541	2	–	–	143	10	6	820
gas	$000	–	–	80	10 616	3 130	44 147	204	–	–	13 871	970	596	73 615
Molybdenum	t	–	–	–	–	–	–	–	–	–	12 388	–	–	12 388
	$000	–	–	–	–	–	–	–	–	–	107 737	–	–	107 737
Gypsum	000 t	x	–	6 331	x	–	1 459	227	–	–	428	–	–	8 522
	$000	1 075	–	58 243	19	–	19 712	3 655	–	–	4 970	–	–	87 674
Total leading minerals	$000	842 007[1]	2 625	388 105[1]	602 177[1]	1 489 955[1]	6 725 836[1]	1 632 038[1]	2 129 369[1]	14 882 412	3 952 822	364 541[1]	929 830	36 159 004
Total all minerals	$000	888 476	2 625	461 063	831 055	2 716 152	7 154 383	1 680 477	3 045 501	14 906 395	3 992 149	465 530	936 286	37 080 092
Leading minerals as % of all minerals		99 3	100 0	84 2[2]	72 5[2]	54 9[2]	94 0[2]	97 1[2]	69 9[2]	99 8	99 0	78.3[2]	99.3	97 5

[1] The values of copper, gold, iron ore, lead, lime, platinum group, potash, salt, sand and gravel, silver and zinc are excluded as they are confidential [2] Percentages exclude those values which are confidential.

^{p} Preliminary; – Nil; .. Amount too small to be expressed; x Confidential

Note: Totals may not add due to rounding

TABLE 6. CANADA, VALUE OF MINERAL PRODUCTION BY PROVINCES AND TERRITORIES, 1982–88

	1982	1983	1984	1985	1986	1987	1988^{p}
				($ million)			
Alberta	20 913	24 103	26 429	27 030	16 331	17 080	14 906
Ontario	3 148	3 687	4 531	4 630	4 825	5 636	7 154
British Columbia	2 769	2 903	3 346	3 541	3 160	3 614	3 992
Saskatchewan	2 313	2 843	3 758	3 797	2 525^{r}	3 151	3 046
Quebec	2 064	2 039	2 167	2 243	2 191	2 781	2 716
Manitoba	530	733	812	862	764	1 000	1 680
Northwest Territories	503	595	777	865	788	869	936
Newfoundland	647	807	979	870	817	743	888
New Brunswick	493	506	613	509	502	622	831
Yukon	169	63	70	60	176	437	466
Nova Scotia	281	260	304	321^{r}	367	407	461
Prince Edward Island	2	1	2	2	2	3	3
Total	33 831	38 539	43 789	44 730^{r}	32 446^{r}	36 342	37 080

^{p} Preliminary; ^{r} Revised.
Note: Totals may not add due to rounding.

TABLE 7. CANADA, PERCENTAGE CONTRIBUTION OF PROVINCES AND TERRITORIES TO TOTAL VALUE OF MINERAL PRODUCTION, 1982–88

	1982	1983	1984	1985	1986	1987	1988^{p}
Alberta	61.8	62.5	60.4	60.4	50.4	47.0	40.2
Ontario	9.3	9.6	10.3^{r}	10.4	14.9	15.5	19.3
British Columbia	8.2	7.5	7.6	7.9	9.7	9.9	10.8
Saskatchewan	6.8	7.4	8.6	8.5	7.8^{r}	8.7	8.2
Quebec	6.1	5.3	4.9^{r}	5.0	6.8	7.7	7.3
Manitoba	1.6	1.9	1.9	1.9	2.4	2.8	4.5
Northwest Territories	1.5	1.5	1.8	1.9	2.4	2.4	2.5
Newfoundland	1.9	2.1	2.2	1.9	2.5	2.0	2.4
New Brunswick	1.5	1.3	1.4	1.1	1.5	1.7	2.2
Yukon	0.5	0.2	0.2	0.1	0.5	1.2	1.3
Nova Scotia	0.8	0.7	0.7	0.7	1.1	1.1	1.2
Prince Edward Island	. . .^{r}	. . .	. . .	. . .	. . .	. . .	. . .
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

^{p} Preliminary; ^{r} Revised; . . . Amount too small to be expressed.
Note: Totals may not add due to rounding.

TABLE 8. CANADA'S WORLD ROLE AS A PRODUCER OF CERTAIN IMPORTANT MINERALS, 1986p

		World	Rank of Five Leading Countries				
			1	2	3	4	5
Uranium (U concentrates)[1]			**Canada**	U.S.A.	South Africa	Australia	Namibia
	t	37 110	11 720	5 200	4 610	4 150	3 300
	% of western world total		31.6	14.0	12.4	11.2	8.9
Zinc (mine production)			**Canada**	U.S.S.R.	Australia	Peru	Mexico
	000 t	6 547	988	970	690	598	285
	% of world total		15.1	14.8	10.5	9.1	4.4
Potash (K$_2$O equivalent)			U.S.S.R.	**Canada**	East Germany	West Germany	France
	000 t	28 523	10 200	6 697	3 485	2 162	1 610
	% of world total		35.8	23.5	12.2	7.6	5.6
Nickel (mine production)			U.S.S.R.	**Canada**	Australia	New Caledonia	Indonesia
	000 t	775	170	164	79	71	67
	% of world total		21.9	21.2	10.2	9.2	8.6
Titanium concentrates (ilmenite)			Australia	**Canada**	Norway	South Africa	U.S.S.R.
	000 t	4 587	1 315	844	771	454	445
	% of world total		28.7	18.4	16.8	9.9	9.7
Sulphur, elemental			U.S.A.	**Canada**	U.S.S.R.	Poland	Mexico
	000 t	36 159	9 859	5 750	5 230	4 893	2 105
	% of world total		27.3	15.9	14.5	13.5	5.8
Asbestos			U.S.S.R.	**Canada**	Brazil	Zimbabwe	China
	000 t	4 544	2 900	662	175	174	150
	% of world total		63.8	14.6	3.9	3.8	3.3
Gypsum			U.S.A.	**Canada**	Japan	France	Spain
	000 t	83 827	14 787	8 803	6 169	5 534	5 443
	% of world total		17.6	10.5	7.4	6.6	6.5
Molybdenum (Mo content)			U.S.A.	Chile	**Canada**	U.S.S.R.	China
	t	99 207	40 315	16 581	12 226	11 200	9 070
	% of world total		40.6	16.7	12.3	11.3	9.1
Aluminum (primary metal)			U.S.A.	U.S.S.R.	**Canada**	Australia	West Germany
	000 t	15 506	3 037	2 350	1 355	875	764
	% of world total		19.6	15.2	8.7	5.6	4.9
Platinum group metals (mine production)			U.S.S.R.	South Africa	**Canada**	Australia	Colombia
	kg	247 115	119 748	111 973	12 190	498	373
	% of world total		48.5	45.3	4.9	0.2	0.2
Lead (mine production)			U.S.S.R.	Australia	U.S.A.	**Canada**	Mexico
	000 t	3 364	550	435	348	334	197
	% of world total		16.3	12.9	10.3	9.9	5.9
Copper (mine production)			Chile	U.S.A.	U.S.S.R.	**Canada**	Zambia
	000 t	8 415	1 400	1 147	1 030	699	513
	% of world total		16.6	13.6	12.2	8.3	6.1
Silver (mine production)			Mexico	Peru	U.S.S.R.	**Canada**	U.S.A.
	t	13 293	2 308	1 926	1 600	1 088	1 064
	% of world total		17.4	14.5	12.0	8.2	8.0
Cadmium (refined production)			U.S.S.R.	Japan	U.S.A.	**Canada**	Belgium
	t	19 598	2 700	2 489	2 352	1 484	1 380
	% of world total		13.8	12.7	12.0	7.6	7.0
Gold (mine production)			South Africa	U.S.S.R.	U.S.A.	**Canada**	Australia
	t	1 576	640	300	108	103	75
	% of world total		40.6	19.0	6.9	6.5	4.8
Cobalt (mine production)			Zaire	Zambia	U.S.S.R.	**Canada**	Cuba
	t	35 958	20 003	5 761	2 812	2 297	1 406
	% of world total		55.6	16.0	7.8	6.4	3.9

[1] Total of western world

p Preliminary

TABLE 9. CANADA, CENSUS VALUE ADDED, TOTAL ACTIVITY, MINING AND MINERAL MANUFACTURING INDUSTRIES, 1980-86

	1980	1981	1982	1983	1984	1985	1986
				($ million)			
Mining							
Metallic minerals							
Gold	588.8	519.0	566.2	693.6	660.8	635.3	975.3
Silver-lead-zinc	513.6	380.3	351.1	294.2	465.7	275.3	332.2
Nickel-copper-zinc	2 992.2	2 007.9	1 144.9	1 567.3	2 008.1	1 868.5	1 712.9
Iron	1 005.0	1 036.0	761.4	644.6	681.4r	817.1	713.8
Uranium	559.3	610.3	600.1	496.9	772.5	813.1	802.0
Miscellaneous metal mines	243.3	150.2	73.7	33.2	72.1	65.4	54.5
Total	5 902.2	4 703.7r	3 497.4	3 729.8	4 660.6r	4 474.7	4 590.7
Industrial minerals							
Asbestos	473.4	431.5	267.3	252.7	252.7	217.6	157.1
Gypsum	26.9	31.3	26.6	35.1	40.2	50.7	56.6
Peat	42.7	47.8	41.1	43.0	47.1	63.0	74.6
Potash	900.4	889.7	488.5	455.4	717.1	428.8	396.4
Sand and gravel	92.0	98.3	75.6	90.3	104.9	132.9	220.0
Stone	123.4	122.5	109.4	119.5	160.1	207.5	277.6
Miscellaneous nonmetals	152.8	171.0	183.5	201.8	240.5	226.8	289.1
Total	1 811.6	1 792.1r	1 192.0r	1 200.0	1 562.6r	1 327.3r	1 471.3
Fuels							
Coal	621.6	671.1	838.0	911.1r	1 314.2	1 264.5	1 110.4
Petroleum and natural gas	14 917.3	15 924.6	18 899.8	22 171.3	25 008.2r	25 428.7	15 044.3
Total	15 538.9	16 595.7r	19 737.8r	23 082.4r	26 322.4r	26 693.2	16 154.7
Total mining industry	23 252.7	23 091.5r	24 427.2r	28 012.2r	32 545.6r	32 495.2r	22 216.7
Mineral manufacturing							
Primary metal industries							
Primary steel	2 537.9	2 750.9	2 149.9	2 464.9	2 939.6	3 105.9	3 001.6
Steel pipe and tube	297.6	378.3	320.3	213.4	389.6	388.2	331.0
Iron foundries	266.9	266.0	279.9	326.0	447.7	471.5	510.7
Smelting and refining	1 976.9	1 808.9	1 493.0	1 912.4	2 236.9	2 202.4	2 372.8
Aluminum rolling, casting and extruding	273.5	292.8	289.9	328.2	394.7	384.3	424.9
Copper and alloy rolling, casting and extruding	103.7	129.3	101.6	117.7	147.8	134.7	144.0
Metal rolling, casting and extruding, n.e.s.	203.6	210.4	169.2	234.1	323.1	355.2	397.1
Total	5 660.1	5 836.6	4 803.8	5 596.7r	6 879.4r	7 042.2r	7 182.0
Nonmetallic mineral products industries							
Cement industries	357.3	422.2	387.4	407.5	421.9	490.7	500.2
Lime industries	59.5	62.8	60.1	66.2	75.4	70.1	78.0
Concrete products industries	324.6	378.5	349.7	333.6	376.5	463.9	522.2
Ready-mix concrete industries	352.4	430.1	388.6	405.0	397.5	455.3	626.3
Clay products (domestic clay)	84.6	82.0	57.1	78.2	87.7	92.9	129.4
Clay products (imported clay)	51.6	50.9	37.9	37.2	37.3	41.4	98.6
Glass industries	308.1	364.6	339.6	403.8	460.9	466.4	482.4
Glass products industries	143.6	141.0	144.9	209.8	258.1	320.7	294.9
Abrasive industries	92.1	95.9	80.4	91.4	101.9	97.8	100.5
Other nonmetallic mineral products industries	477.5	483.4	426.7	487.6	571.5	672.5	746.0
Total	2 251.3	2 511.4r	2 272.4	2 520.3r	2 788.7r	3 171.8	3 578.6
Petroleum and coal products industries							
Petroleum refining	1 750.1	2 641.5	2 108.4	2 563.7	2 498.2	2 478.8	1 725.0
Manufacturers of lubricating oil and greases	26.7	35.0	31.7	24.8	56.1	75.7	82.5
Other petroleum and coal products industries	36.0	39.3	39.9	52.6	42.1	41.0	98.9
Total	1 812.8	2 715.8	2 180.0r	2 641.1	2 596.4	2 595.5	1 906.3
Total mineral manufacturing	9 724.2	11 063.8r	9 256.2	10 758.1r	12 264.5r	12 809.4r	12 667.0
Total mining and mineral manufacturing	32 976.9r	34 155.3r	33 683.4r	38 770.3r	44 810.1r	45 304.6r	34 883.7

n.e.s. Not elsewhere specified; r Revised.
Note: Totals may not add due to rounding.

TABLE 10. CANADA, GROSS DOMESTIC PRODUCT OF INDUSTRIAL PRODUCTION, MINING AND MINERAL MANUFACTURING AT FACTOR COST, 1981-87

(1981 = 100)	1981	1982	1983	1984	1985	1986	1987[p]
				($ million)			
Total industrial production	88 675.3	80 910.0	84 981.6	91 963.8	96 502.3	96 894.3	108 275.9
Total mining	17 453.5	16 462.9	17 019.1	18 968.4	19 901.4	19 000.1	21 831.5
Metals							
Gold mines	487.0	655.7	732.9	797.7	907.1	1 047.0	1 308.8
Other metal mines	2 514.6	2 134.8	2 229.6	2 545.7	2 495.5	2 607.8	4 211.6
Iron mines	820.7	559.5	528.1	637.6	711.1	680.5	521.7
Fuels							
Crude oil and natural gas	9 787.0	9 836.1	10 115.2	10 618.1	11 141.8	10 906.0	12 161.1
Nonmetals							
Asbestos	358.3	248.7	243.3	240.5	244.8	196.4	165.3
All nonmetals	751.3	572.6	630.3	799.2	699.6	715.8	780.5
Salt	71.0	77.3	81.7	92.9	91.2	98.3	110.9
Coal	466.3	436.9	447.3	656.5	703.2	637.0	1 074.7
Quarry and sand pits	314.6	230.2	219.4	247.9	220.7	243.6	460.0
Services related to mining	1 882.7	1 711.1	1 791.3	2 332.3	2 686.4	1 867.7	1 036.9
Mineral manufacturing							
Primary metals	5 101.0	3 967.1	4 452.1	5 107.2	5 121.5	5 094.7	5 996.2
Primary steel	2 378.2	1 810.2	1 954.6	2 231.9	2 201.5	2 176.8	2 365.3
Steel pipe and tube mills	322.4	206.1	167.4	238.4	252.2	194.2	358.8
Iron foundries	238.8	230.6	234.2	300.6	297.7	310.8	430.5
Nonferrous smelting and refining	1 610.0	1 282.8	1 546.4	1 705.4	1 725.1	1 744.4	2 190.3
Nonmetallic mineral products	2 015.7	1 674.4	1 753.4	1 900.2	2 048.7	2 171.0	2 420.3
Cement	318.5	254.8	245.9	271.8	302.2	320.5	337.0
Concrete products	311.6	257.4	243.5	278.2	326.1	363.7	405.8
Ready-mix concrete	350.8	276.7	281.7	290.4	326.5	362.7	438.1
Glass and glass products	422.0	397.4	466.7	512.7	528.1	528.1	539.6
Miscellaneous nonmetallic products	505.2	418.4	438.2	466.8	474.4	488.1	605.1
Petroleum and coal products	858.8	732.9	695.6	695.5	679.7	677.2	869.4

[p] Preliminary.

TABLE 11. CANADA, GROSS DOMESTIC PRODUCT BY INDUSTRIES AT FACTOR COST, 1981-87

(1981 = 100)	1981	1982	1983	1984	1985	1986	1987^p
				($ million)			
Gross domestic product, all industries	319 537.0	307 521.8	317 201.5	333 274.0	347 708.9	358 938.2	379 041.6
Agriculture	10 611.2	10 933.4	10 610.2	10 810.8	10 703.4	11 579.1	11 774.2
Fishing and trapping	565.3	547.2	541.3	468.5	539.2	579.7	631.4
Forestry	2 045.0	1 849.1	2 352.5	2 078.4	2 199.4	2 366.2	2 647.0
Mines (including milling), quarries and oil wells	17 453.4	16 462.9	17 019.1	18 968.4	19 901.4	19 000.1	21 831.5
Manufacturing	61 648.1	54 844.3	57 954.5	62 200.3	65 190.5	66 255.8	74 506.3
Construction	25 095.1	23 051.3	23 367.7	23 043.0	24 053.6	24 628.5	27 077.1
Transportation and storage	14 428.6	13 222.0	13 928.4	15 117.4	15 814.4	16 183.4	16 792.9
Communications	8 728.3	8 821.5	8 979.7	9 288.6	9 715.9	10 338.4	10 806.7
Electric power, gas and water utilities	8 950.3	8 976.8	9 376.0	10 151.1	10 765.4	10 973.0	11 289.1
Trade, wholesale	15 413.6	13 590.9	14 326.4	15 440.6	16 331.3	17 652.7	20 486.3
Trade, retail	19 661.3	18 860.4	19 731.6	20 800.3	22 388.0	23 238.7	25 309.5
Finance, insurance and real estate	44 155.3	44 690.3	46 177.7	48 698.7	51 447.5	53 390.3	53 994.4
Community, business and personal services	32 911.3	32 644.3	32 487.6	35 017.1	36 468.7	39 079.0	38 680.2
Government service	21 714.9	22 349.1	22 678.4	22 933.4	23 109.6	23 264.1	23 659.6

^{p} Preliminary.

TABLE 12. CANADA, GROSS DOMESTIC PRODUCT FOR SELECTED INDUSTRIES BY PROVINCE, 1985

	Nfld	Prince Edward Island	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Sask	Alberta	British Columbia	Yukon and N W T	Canada
						($ million)						
Agriculture	20 5	121 5	140 5	124 4	1 721 4	2 915 7	962 7	1 742 0	1 755 4	601 5	–	10 105 6
Forestry	54 7	0 3	41 3	200 8	404 0	458 6	20 6	23 7	35 3	1 264 9	–	2 504.1
Fishing, hunting and trapping	99 9	23 4	159 5	46 5	38 7	29 3	13 3	4 8	4 2	149 9	2 9	572 6
Mining[1]	484 3	0 1	260 8	191 4	779 0	2 211 4	424 1	2 437 6	16 555 4	1 701 2	492 0	25 537 4
Manufacturing	483 1	83 4	1 336 7	982 8	19 914 4	41 103 9	1 821 4	783 6	3 668 2	6 106 5	16 7	76 300 7
Construction	484 2	93 1	750 7	573 9	5 509 8	7 912 4	825 1	1 125 5	3 711 1	3 092 6	238 0	24 316 0
Electric power, gas and water utilities	341 0	19 6	293 0	442 6	4 126 3	4 658 4	568 9	413 6	1 467 2	1 452 4	55 0	13 838 2
Goods-producing industries	1 967 7	341 4	2 982 5	2 562 4	32 493 6	59 289 7	4 636 1	6 530 8	27 196 8	14 369 0	804 6	153 174 6

[1] Cement, lime, clay and clay products (domestic clays) industries are included under "manufacturing"

– Nil.

TABLE 13. CANADA, GROSS DOMESTIC PRODUCT FOR MINING BY PROVINCE, 1979–84

	Nfld	Prince Edward Island	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Sask	Alberta	British Columbia	Yukon and N W T	Canada
						($ million)						
1979	475 6	0 1	102 4	206 4	989 5	1 600 8	354 5	1 014 2	7 409 6	1 621 4	440 4	14 214 8
1980	445 1	0 1	116 1	96 2	1 223 1	2 476 9	428 6	1 304 4	10 033 1	1 479 5	516 7	18 119 5
1981	471 8	0 1	124 9	125 9	1 099 6	1 883 6	290 3	1 298 5	10 593 0	1 264 6	358 4	17 510 6
1982	313 0	0 1	190 0	124 5	866 5	1 356 1	282 2	1 294 3	12 531 2	1 209 7	412 8	18 580 3
1983	367 8	0 1	277 4	94 2	853 6	1 689 4	352 6	1 640 9	14 648 1	1 319 5	443 9	21 687 6
1984	484 3	0 1	260 8	191 4	779 0	2 211 4	424 1	2 437 6	16 555 4	1 701 2	492 0	25 537 4

TABLE 14. CANADA, GROSS DOMESTIC PRODUCT FOR MINERAL MANUFACTURING BY PROVINCE, 1984

	Primary Metal Fabrication	Nonmetallic Mineral Products Manufacturing	Petroleum and Coal Products Manufacturing	Mineral Manufacturing
		($ millions)		
Newfoundland	x	x	x	x
Prince Edward Island	–	x	–	x
Nova Scotia	x	x	x	x
New Brunswick	x	x	x	x
Quebec	1 731.0	x	494.5	x
Ontario	3 365.2	1 190.0	643.6	5 198.8
Manitoba	117.5	54.8	x	x
Saskatchewan	x	44.8	x	x
Alberta	293.7	207.7	265.6	767.0
British Columbia	406.2	197.9	183.9	788.0
Yukon and Northwest Territories	–	–	x	x
Canada	6 005.4	2 289.7	1 801.2	10 096.3

x Confidential, included in total; – Nil.

TABLE 15. CANADA, VALUE OF MINERAL EXPORTS, 1981-87

	1981	1982	1983	1984	1985	1986	1987^p
				($ million)			
Ferrous							
Crude material	1 540.7	1 103.7	1 053.4	1 207.0	1 291.9	1 217.4	1 120.4
Smelted and refined material	475.1	232.6	300.3	247.8	242.1	278.0	219.2
Semi-fabricated material	1 874.8	1 763.7	1 360.7	2 007.0	2 158.2	2 171.9	2 483.7
Total	3 890.5	3 100.1	2 714.4	3 461.8	3 692.2	3 667.2	3 823.3
Nonferrous							
Crude material	1 707.0	1 346.7	1 323.3	1 462.2	1 334.9	1 527.1	1 886.1
Smelted and refined material	5 836.5	4 982.1	5 620.4	6 630.7	6 278.5	7 607.5	6 440.1
Semi-fabricated material	586.9	544.1	638.1	873.6	798.4	865.5	1 062.9
Total	8 130.4	6 872.9	7 581.8	8 966.5	8 411.9	10 000.1	9 389.1
Nonmetals							
Crude material	2 682.2	2 202.2	2 217.1	2 882.7	3 084.3	2 841.2	2 703.6
Smelted and refined material	-	-	-	-	-	-	-
Semi-fabricated material	711.2	664.2	657.2	891.7	916.1	982.1	1 015.9
Total	3 393.4	2 866.4	2 874.3	3 774.4	4 000.4	3 823.3	3 719.5
Mineral fuels							
Crude material	8 201.3	9 111.0	8 679.4	10 507.4	12 236.6	8 316.5	9 330.4
Smelted and refined material	2 800.2	2 364.1	2 717.0	3 252.0	3 445.8	2 578.1	2 616.2
Semi-fabricated material	512.9	607.8	466.1	485.2	485.5	183.3	192.3
Total	11 514.4	12 083.0	11 862.6	14 244.6	16 167.8	11 077.9	12 138.9
Total minerals and products							
Crude material	14 131.2	13 763.6	13 273.3	16 059.4	17 947.7	13 902.1	15 040.5
Smelted and refined material	9 111.8	7 578.8	8 637.7	10 130.5	9 966.4	10 463.6	9 275.5
Semi-fabricated material	3 685.8	3 579.9	3 122.1	4 257.6	4 358.2	4 202.7	4 754.7
Total	26 928.8	24 922.3	25 033.0	30 447.5	32 272.3	28 568.4	29 070.7

^{p} Preliminary; - Nil.

TABLE 16. CANADA, VALUE OF MINERAL IMPORTS, 1981-87

	1981	1982	1983	1984	1985	1986	1987ᵖ
				($ million)			
Ferrous							
Crude material	373.2	227.3	285.2	398.9	427.0	360.6	331.1
Smelted and refined material	205.2	86.2	93.9	174.0	162.7	212.0	353.8
Semi-fabricated material	2 127.0	1 193.2	1 114.8	1 502.6	1 885.0	1 672.2	1 774.9
Total	2 705.4	1 506.7	1 493.8	2 075.5	2 474.7	2 244.8	2 461.7
Nonferrous							
Crude material	1 219.3	1 001.7	1 125.8	1 132.3	909.0	1 236.9	906.7
Smelted and refined material	1 910.7	1 441.2	1 835.8	1 882.5	2 247.1	2 672.5	1 994.0
Semi-fabricated material	701.6	525.6	603.4	900.7	836.6	960.8	1 116.7
Total	3 831.5	2 968.4	3 565.0	3 915.5	4 019.7	4 870.2	4 017.3
Nonmetals							
Crude material	349.2	290.3	277.8	334.3	344.2	354.1	383.0
Smelted and refined material	-	-	-	-	-	-	-
Semi-fabricated material	1 008.2	837.8	958.5	1 121.7	1 304.1	1 382.8	1 514.0
Total	1 357.4	1 128.1	1 236.3	1 456.0	1 648.3	1 736.9	1 896.9
Mineral fuels							
Crude material	8 839.7	5 912.6	4 162.0	4 470.8	4 584.3	3 630.6	3 906.7
Smelted and refined material	713.6	683.5	862.7	1 445.4	1 418.0	1 327.9	1 412.7
Semi-fabricated material	228.1	210.2	227.9	326.7	420.0	401.4	477.3
Total	9 781.4	6 806.3	5 252.6	6 242.9	6 422.2	5 359.9	5 796.8
Total minerals and products							
Crude material	10 781.4	7 431.8	5 850.8	6 336.2	6 264.5	5 582.2	5 529.4
Smelted and refined material	2 829.5	2 210.8	2 792.4	3 501.9	3 827.8	4 212.3	3 760.5
Semi-fabricated material	4 064.9	2 766.9	2 904.6	3 851.7	4 472.6	4 417.2	4 882.8
Total	17 675.7	12 409.5	11 547.8	13 689.8	14 564.9	14 211.8	14 172.8

ᵖ Preliminary; - Nil.

TABLE 17. CANADA, VALUE OF MINERAL EXPORTS IN RELATION TO TOTAL DOMESTIC EXPORT TRADE, 1977, 1982 AND 1987

	1977		1982		1987ᵖ	
	($ million)	(%)	($ million)	(%)	($ million)	(%)
Crude material	7 871.4	18.0	13 763.6	16.8	15 040.5	12.4
Smelted and refined material	3 865.8	8.8	7 578.8	9.3	9 275.5	7.6
Semi-fabricated material	1 681.1	3.8	3 579.9	4.4	4 754.7	3.9
Total	13 418.4	30.7	24 922.3	30.5	29 070.7	23.9
Total exports, all products	43 684.6	100.0	81 824.8	100.0	121 462.3	100.0

ᵖ Preliminary.

TABLE 18. CANADA, VALUE OF MINERAL IMPORTS IN RELATION TO TOTAL IMPORT TRADE, 1977, 1982 AND 1987

	1977		1982		1987ᵖ	
	($ million)	(%)	($ million)	(%)	($ million)	(%)
Crude material	4 463.5	10.7	7 431.8	11.1	5 529.4	4.8
Smelted and refined material	713.5	1.7	2 210.8	3.3	3 760.5	3.2
Semi-fabricated material	1 843.7	4.4	2 766.9	4.2	4 882.8	4.2
Total	7 020.7	16.9	12 409.5	18.6	14 172.8	12.2
Total imports, all products	41 523.0	100.0	66 738.5	100.0	116 075.7	100.0

ᵖ Preliminary; ʳ revised.

TABLE 19. CANADA, VALUE OF MINERAL EXPORTS BY MAIN GROUPS AND DESTINATION, 1987p

	United States	United Kingdom	EFTA[1]	EEC[2]	Japan	Other Countries	Total
				($ million)			
Ferrous materials and products	2 910.8	210.6	15.2	341.6	60.5	284.7	3 823.3
Nonferrous materials and products	5 435.3	587.4	293.3	864.8	1 357.8	850.4	9 389.0
Nonmetallic mineral materials and products	1 833.6	30.6	21.2	387.3	130.9	1 315.8	3 719.5
Mineral fuels, materials and products	10 031.9	73.6	29.2	304.5	1 268.0	431.6	12 138.9
Total	20 211.6	902.3	358.9	1 898.1	2 817.3	2 882.5	29 070.7
Percentage of total mineral exports	69.5	3.1	1.2	6.5	9.7	9.9	100.0

[1] European Free Trade Association includes Austria, Norway, Sweden, Switzerland, Finland and Iceland. [2] European Economic Community includes Belgium-Luxembourg, France, Italy, Netherlands, West Germany, Greece, Denmark, Portugal, Spain and Ireland.
p Preliminary

TABLE 20. CANADA, VALUE OF MINERAL IMPORTS BY MAIN GROUPS AND ORIGIN, 1987p

	United States	United Kingdom	EFTA[1]	EEC[2]	Japan	Other Countries	Total
				($ million)			
Ferrous materials and products	1 209.6	173.8	99.7	501.6	171.0	306.0	2 461.7
Nonferrous materials and products	2 780.3	49.8	47.5	207.3	44.9	887.5	4 017.3
Nonmetallic mineral materials and products	1 302.2	36.8	26.6	336.2	38.7	156.5	1 896.9
Mineral fuels, materials and products	2 026.5	1 785.6	107.7	188.7	8.0	1 680.2	5 796.8
Total	7 318.6	2 046.0	281.5	1 233.8	262.5	3 030.3	14 172.8
Percentage of total mineral imports	51.6	14.4	2.0	8.7	1.9	21.4	100.0

[1] European Free Trade Association includes Austria, Norway, Sweden, Switzerland, Finland and Iceland. [2] European Economic Community includes Belgium-Luxembourg, France, Italy, Netherlands, West Germany, Greece, Denmark, Portugal, Spain and Ireland.
p Preliminary

TABLE 21. CANADA, VALUE OF MINERAL EXPORTS, BY COMMODITY AND DESTINATION, 1987[p]

	United States	United Kingdom	EFTA[1]	EEC[2]	Japan	Other Countries	Total
				($ 000)			
Petroleum	6 227 713	4 091	831	2 165	67 664	64 099	6 366 563
Natural gas	3 189 997	-	-	2	-	452	3 190 451
Aluminum	2 288 960	12 463	19 782	73 828	247 163	322 594	2 964 790
Iron and steel	2 362 168	6 940	5 389	66 460	1 443	229 232	2 671 632
Coal	36 367	16 775	19 629	86 453	1 188 266	348 064	1 695 554
Copper	677 296	91 012	54 261	121 180	457 461	131 225	1 532 434
Gold	867 813	1 781	25 153	142 307	377 096	39 959	1 454 109
Nickel	402 873	192 784	159 577	124 937	63 300	194 978	1 138 449
Iron ore	526 785	203 619	9 817	274 996	51 613	53 519	1 120 349
Potash	513 415	2 500	6 709	45 579	68 308	328 664	965 175
Sulphur	95 996	19	-	90 964	1 039	723 105	911 123
Uranium	577 793	52 747	8 747	215 871	12 119	19 017	886 294
Zinc	405 205	37 439	11 120	200 402	50 258	84 006	788 430
Asbestos	39 612	11 583	10 451	96 030	40 528	178 912	377 116
Silver	164 961	1 302	2 608	25 940	58 898	10 033	263 742
All other minerals	1 834 615	267 200	24 834	331 022	132 147	154 689	2 744 507
Total	20 211 569	902 255	358 908	1 898 136	2 817 303	2 882 548	29 070 718

[1] European Free Trade Association includes Austria, Norway, Sweden, Switzerland, Finland and Iceland [2] European Economic Community includes Belgium-Luxembourg, France, Italy, Netherlands, West Germany, Greece, Denmark, Portugal, Spain and Ireland.

[p] Preliminary; - Nil.

TABLE 22. CANADA, VALUE OF MINERAL IMPORTS, BY COMMODITY AND ORIGIN, 1987[p]

	United States	United Kingdom	EFTA[1]	EEC[2]	Japan	Other Countries	Total
				($ 000)			
Petroleum	1 209 415	1 785 508	107 694	188 205	7 974	1 677 115	4 975 911
Iron and steel	842 837	173 520	89 442	490 796	170 976	268 686	2 036 257
Aluminum	904 535	11 215	5 703	100 572	31 110	366 706	1 419 841
Gold	805 754	113	10 001	2 112	-	219 373	1 037 353
Coal	801 270	-	-	57	-	3 038	804 365
Clays	309 629	7 578	3 898	122 197	17 984	20 320	481 606
Copper	290 297	3 656	11 017	26 893	7 511	104 575	443 949
Platinum Group Metals	373 692	10 949	528	9 041	-	33 826	428 036
Iron ore	323 398	8	60	152	-	9 457	333 075
Phosphatic materials	221 633	150	80	3 413	127	14 690	240 093
Abrasives	111 679	2 600	9 486	25 265	2 248	3 462	154 740
Nickel	60 235	10 676	13 379	7 805	25	15 104	107 224
Stone, building	25 761	236	1 363	48 301	-	6 455	82 116
Graphite	63 491	407	2 039	5 189	4 511	874	76 511
Mineral pigments	40 235	1 554	54	12 310	-	4 253	58 406
All other minerals	934 711	37 879	26 785	191 490	20 047	282 385	1 493 297
Total	7 318 572	2 046 049	281 529	1 233 798	262 513	3 030 319	14 172 780

[1] European Free Trade Association includes Austria, Norway, Sweden, Switzerland, Finland and Iceland. [2] European Economic Community includes Belgium-Luxembourg, France, Italy, Netherlands, West Germany, Greece, Denmark, Portugal, Spain and Ireland.

[p] Preliminary; - Nil

TABLE 23. CANADA, PHYSICAL VOLUME OF IMPORT TRADE FOR SELECTED COMMODITIES, 1981-87

	Units of Weight	1981	1982	1983	1984	1985	1986	1987^p
Crude materials								
Metals								
Iron ore	t	5 794 713	3 359 304	4 013 119	4 946 916	5 800 222	5 367 244	5 212 745
Alumina	t	1 020 550	939 268	1 063 176	1 349 213	1 544 007	1 724 599	2 068 422
Bauxite ore	t	2 734 665	2 574 719	2 329 911	2 451 541	2 074 206	2 112 905	2 019 148
Manganese ore	t	119 746	71 655	42 261	77 546	102 202	94 916	80 959
Nonmetals								
Limestone, crushed	t	2 526 876	1 485 428	1 799 859	1 944 045	2 071 651	2 354 276	2 691 937
Phosphate rock	t	3 245 446	2 477 199	2 625 390	3 142 654	2 621 668	2 355 682	1 968 225
Sand and gravel	t	1 446 872	1 179 284	878 613	1 266 983	1 111 801	1 047 189	1 268 392
Salt and brine	t	1 254 992	1 526 880	777 311	1 053 210	1 255 510	1 328 247	1 112 119
Silica sand	t	1 142 880	788 768	982 664	1 076 083	983 340	1 055 215	836 427
Clay, ground and unground	t	413 038	345 384	368 996	403 481	472 755	527 371	643 533
Bentonite	t	311 249	238 027	187 229	377 054	346 018	326 028	318 074
Gypsum	t	143 499	93 844	100 938	131 809	121 802	221 644	217 623
Fluorspar	t	173 598	126 594	141 928	166 710	111 726	164 114	134 566
Fuels								
Coal	t	14 993 112	15 715 860	14 822 356	19 060 700	15 024 782	13 368 536	14 150 394
Petroleum, crude	m^3	30 751 766	19 670 772	14 603 437	14 849 581	15 845 864	20 153 969	21 753 201
Fabricated materials								
Metals								
Steel								
sheets and strips	t	1 733 683	540 408	536 819	699 381	1 069 154	914 822	962 184
bars and rods	t	340 775	219 629	277 287	405 194	363 979	407 982	425 736
pipes and tubes	t	364 979	249 661	217 054	315 817	455 375	254 206	292 649
structural shapes	t	364 384	120 369	162 133	234 614	232 618	209 380	254 119
castings and forgings, n.e.s.	t	118 491	70 130	92 522	135 892	113 200	101 711	136 505
Aluminum products	t	122 164	99 550	120 384	185 199	175 461	179 205	213 679
Ferroalloys	t	117 911	64 662	71 560	106 568	124 770	93 992	124 740
Nonmetals								
Cement	t	721 206	231 829	238 268	236 230	372 800	489 953	586 155
Phosphate fertilizers	t	307 217	249 827	360 302	333 765	444 135	439 547	486 055
Fire bricks	t	187 020	132 601	154 765	177 126	167 202	154 256	155 712
Fuels								
Fuel oil	000 L	1 256 790	1 571 003	1 446 255	2 399 279	2 073 480	2 618 806	3 087 032
Coke, petroleum	t	935 929	650 813	768 981	886 734	1 641 841	910 620	948 027
Coke, n.e.s.	t	500 146	400 506	585 859	660 258	783 718	881 086	699 015

^{p} Preliminary; n.e.s. Not elsewhere specified.

TABLE 24. CANADA, PHYSICAL VOLUME OF EXPORT TRADE FOR SELECTED COMMODITIES, 1981-87

	Units of Weight	1981	1982	1983	1984	1985	1986	1987^p
Crude material								
Metals								
Iron, ores	t	41 452 042	27 281 399	25 527 964	30 737 466	32 259 296	31 008 240	29 679 318
Zinc, ores and concentrates	t	516 214	457 753	626 174	550 213	396 103	450 249	613 185
Copper, ores and concentrates	t	276 810	257 930	313 798	332 373	320 619	341 641	381 126
Lead, ores and concentrates	t	146 304	106 744	85 458	114 720	93 657	118 373	207 936
Nonmetals								
Potash	t	10 067 830	7 221 375	9 411 895	11 493 732	9 980 965	9 894 036	10 983 051
Sulphur, crude	t	7 309 215	6 111 447	5 670 281	7 326 852	7 818 425	6 257 074	6 571 811
Gypsum	t	5 094 872	4 775 780	5 187 032	6 224 573	5 879 664	5 921 982	5 704 853
Salt and brine	t	1 507 708	1 721 892	1 914 626	2 545 011	2 263 076	2 502 518	1 924 686
Limestone, crushed	t	1 758 298	1 517 498	1 390 795	1 216 674	1 195 939	1 350 345	1 709 483
Asbestos, crude and fibers	t	1 062 287	880 703	753 901	796 764	722 003	717 668	648 836
Crude refractory materials	t	629 770	40 838	241 131	579 487	534 579	728 668	506 722
Sand and gravel	t	318 634	168 691	95 634	109 809	241 790	249 833	414 547
Nepheline syenite	t	476 280	414 781	398 295	387 066	351 026	338 257	356 141
Fuels								
Coal	t	16 285 101	15 528 538	16 974 344	24 354 894	27 591 769	25 899 699	25 466 331
Natural gas	000 m^3	21 689 360	22 072 136	19 296 956	21 427 034	26 154 592	21 388 902	27 672 088
Semi-fabricated materials								
Metals								
Aluminum, pig ingots	t	725 442	896 370	925 398	833 631	1 050 789	1 163 709	1 171 844
Iron, pig ingots	t	466 358	485 621	348 280	392 135	574 111	519 562	446 953
Zinc, pig ingots	t	453 464	470 396	500 454	529 653	555 621	427 176	441 227
Copper, refinery shapes	t	263 045	232 625	298 527	345 985	280 033	306 822	288 800
Lead, pig ingots	t	119 814	146 127	147 270	234 429	113 993	111 831	100 204
Nonmetals								
Cement	t	1 578 658	1 752 113	1 512 563	2 130 111	2 485 699	2 635 244	2 802 966
Peat	t	326 826	356 027	396 879	460 600	446 521	535 003	477 342
Lime, quick and hydrated	t	432 845	281 248	215 945	186 746	194 097	189 509	163 768
Fuels								
Fuel oil	000 L	3 846 906	2 721 922	3 825 520	4 424 697	4 667 298	4 721 263	5 712 282
Butane gas, liquefied	000 L	3 137 545	3 572 546	3 011 824	3 278 444	3 685 449	2 858 169	3 399 518
Propane gas, liquefied	000 L	3 867 950	4 513 705	3 534 575	3 887 986	3 172 345	2 664 951	3 092 420
Gasoline	000 L	600 969	536 268	1 240 028	1 583 578	2 382 777	2 080 192	2 022 160
Coke, n e s	t	192 515	129 793	45 607	116 225	169 069	114 410	151 974

^{p} Preliminary, n e s Not elsewhere specified

TABLE 25. CANADA, MAJOR MINERAL EXPORT DESTINATIONS BY CLASS OF PRODUCT, VALUE AND PERCENTAGE, 1987

	Crude		Smelted and Refined		Semi-fabricated		Total	
	Value	Percentage	Value	Percentage	Value	Percentage	Value	Percentage
	($ million)	(%)	($ million)	(%)	($ million)	(%)	($ million)	(%)
United States	9 475.1	63.0	6 551.9	70.6	4 184.6	88.0	20 211.7	69.5
Japan	2 134.3	14.2	637.9	6.9	45.2	1.0	2 817.3	9.7
United Kingdom	431.3	2.9	388.4	4.2	82.5	1.7	902.3	3.1
Belgium-Luxembourg	315.7	2.1	252.9	2.7	30.9	0.6	599.5	2.1
Korea, South	377.7	2.5	126.0	1.4	8.9	0.2	512.6	1.8
France	222.4	1.5	152.0	1.6	4.1	0.1	378.5	1.3
Germany, West	225.2	1.5	80.7	0.9	19.1	0.4	325.0	1.1
Netherlands	158.7	1.1	93.5	1.0	9.1	0.2	261.4	0.9
Brazil	223.2	1.5	10.5	0.1	6.6	0.1	240.3	0.8
Taiwan	101.8	0.7	88.0	0.9	31.4	0.7	221.2	0.8
Norway	24.9	0.2	171.1	1.8	1.9	. . .	197.9	0.7
Italy	145.1	1.0	41.7	0.4	9.9	0.2	196.7	0.7
Morocco	190.1	1.3	–	–	0.5	. . .	190.6	0.7
Mexico	74.1	0.5	7.3	0.1	68.0	1.4	149.4	0.5
China	76.6	0.5	64.1	0.7	6.1	0.1	146.9	0.5
Australia	99.1	0.7	6.0	0.1	18.4	0.4	123.5	0.4
Indonesia	73.1	0.5	7.9	0.1	8.6	0.2	89.6	0.3
India	67.1	0.4	1.0	. . .	18.4	0.4	86.5	0.3
Turkey	14.4	0.1	63.1	0.7	0.5	. . .	77.9	0.3
Hong Kong	12.0	0.1	53.0	0.6	12.5	0.3	77.5	0.3
Thailand	30.6	0.2	16.8	0.2	21.3	0.4	68.7	0.2
Sweden	21.7	0.1	41.6	0.4	3.3	0.1	66.6	0.2
Tunisia	61.1	0.4	0.7	0.1	–	–	61.8	0.2
Spain	28.5	0.2	26.8	0.3	2.1	. . .	57.4	0.2
Other countries	456.7	3.0	392.6	4.2	160.8	3.3	1 010.2	3.5
Total	15 040.5	100.0	9 275.5	100.0	4 754.7	100.0	29 070.7	100.0

– Nil; . . . Amount too small to be expressed.

TABLE 26. CANADA, MAJOR MINERAL IMPORT ORIGINS BY CLASS OF PRODUCT, VALUE AND PERCENTAGE, 1987

	Crude		Smelted and Refined		Semi-fabricated		Total	
	Value	Percentage	Value	Percentage	Value	Percentage	Value	Percentage
	($ million)	(%)	($ million)	(%)	($ million)	(%)	($ million)	(%)
United States	2 078.4	37.6	2 191.7	58.2	3 048.4	62.4	7 318.6	51.6
United Kingdom	1 737.7	31.4	127.1	3.4	181.2	3.7	2 046.0	14.4
Venezuela	251.7	4.6	241.9	6.4	49.5	1.0	543.0	3.8
Germany, West	1.0	...	72.1	1.9	238.3	4.9	311.4	2.2
Japan	...	...	29.1	0.8	233.4	4.8	262.5	1.9
Australia	61.3	1.1	175.4	4.7	12.2	0.3	248.9	1.8
Nigeria	238.4	4.3	–	–	–	–	238.4	1.7
Mexico	159.7	2.9	30.1	0.8	22.1	0.5	211.9	1.5
Italy	14.9	0.3	38.6	1.0	157.1	3.2	210.7	1.5
Belgium-Luxembourg	0.6	...	26.6	0.7	163.4	3.3	190.6	1.3
France	8.5	0.2	27.4	0.7	144.9	3.0	180.8	1.3
Saudi Arabia	156.6	2.8	16.6	0.4	–	–	173.2	1.2
Spain	3.3	0.1	47.1	1.3	96.9	2.0	147.2	1.0
Brazil	26.9	0.5	59.3	1.6	60.2	1.2	146.4	1.0
Netherlands	1.0	...	94.0	2.5	38.7	0.8	133.7	1.0
Norway	82.0	1.5	29.2	0.8	15.6	0.3	126.9	1.0
Uruguay	–	–	119.5	3.2	0.5	...	120.0	1.0
Iran	94.4	1.7	–	–	–	–	94.4	0.7
Jamaica	0.2	...	92.0	2.4	–	–	92.2	0.7
Korea, South	–	–	–	–	83.4	1.7	83.4	0.6
Iraq	79.4	1.4	–	–	–	–	79.4	0.6
Sweden	0.5	...	0.9	...	73.1	1.5	74.5	0.5
Chile	52.5	0.9	10.4	0.3	4.9	0.1	67.7	0.5
South Africa	17.6	0.3	36.2	1.0	5.1	0.1	58.9	0.4
Other countries	462.8	8.4	295.3	7.9	253.9	5.2	1 012.0	7.1
Total	5 529.4	100.0	3 760.5	100.0	4 882.8	100.0	14 172.7	100.0

– Nil; . . . Amount too small to be expressed.

TABLE 27. CANADA, APPARENT CONSUMPTION[1] OF SOME MINERALS AND RELATION TO PRODUCTION[2], 1985-87

	1985			1986			1987ᵖ		
	Apparent Consumption	Production	Consumption as % of Production	Apparent Consumption	Production	Consumption as % of Production	Apparent Consumption	Production	Consumption as % of Production
	(tonnes)			(tonnes)			(tonnes)		
Quartz silica	3 550 246	2 668 650	133.0	3 620 295	2 640 436	137.1	3 349 191	2 560 411	130.8
Lime	2 040 539	2 211 580	92.3	2 099 987	2 242 577	93.6	2 151 024	2 270 500	94.7
Salt	9 077 131	10 084 697	90.0	9 157 575	10 331 846	88.6	9 481 133	10 293 700	92.1
Cement	8 079 543	10 192 442	79.3	8 465 932	10 611 223	79.8	9 988 189	12 205 000	81.8
Gypsum	2 002 921	7 760 783	25.8	3 102 467	8 802 805	35.2	3 324 306	8 811 536	37.7
Iron ore	12 978 150	39 501 601	32.9	10 354 224	36 166 884	28.6	12 777 871	37 552 400	34.0
Potash (K_2O)	593 592	6 661 077	8.9	735 687	6 752 709	10.9	779 491	7 464 930	10.4
Asbestos	28 561	750 190	3.8	–	662 381	–	16 702	665 300	2.5

[1] "Apparent consumption" is production, plus imports, less exports. [2] "Production" refers to producers' shipments.
ᵖ Preliminary; – Nil.

TABLE 28. CANADA, REPORTED CONSUMPTION OF MINERALS AND RELATION TO PRODUCTION, 1985-87

	Unit of Measure	1985			1986			1987		
		Consumption	Production	Consumption as % of Production	Consumption	Production	Consumption as % of Production	Consumption	Production	Consumption as % of Production
Metals										
Aluminum	t	346 033	1 282 316	27.0	393 270r	1 355 161	29.0r	421 392	1 540 439	27.4
Antimony	kg	184 993	1 075 627	17.2	539 655	3 805 138	14.2	540 147	3 705 613	14.6
Bismuth	kg	7 284	201 489	3.6	6 617	152 930	4.3	4 547	165 282	2.8
Cadmium	kg	29 682	1 716 731	1.7	17 372r	1 483 907	1.2r	18 919	1 483 907	1.3
Chromium (chromite)	t	17 555	-	..	20 935	-	..	23 000	-	..
Cobalt	kg	101 167	2 066 815	4.9	96 172	2 297 178	4.2	120 289	2 490 020	4.8
Copper[1]	t	203 335	738 637	27.5	204 685	698 527	29.3	215 677	794 149	27.2
Lead[2]	t	104 447r	268 292	38.9r	94 680r	334 342	28.3r	102 894	373 215	27.6
Magnesium	t	6 582	x	..	6 731	x	..	6 398	x	..
Manganese ore	t	160 241	-	..	199 699r	-	..	220 053	-	..
Mercury	kg	41 462	-	..	52 076	-	..	35 714	-	..
Molybdenum (Mo content)	t	772	7 852	9.8	684	11 251	6.1	953	14 771	6.5
Nickel	t	7 206r	169 971	4.2r	8 864r	163 639	5.4r	9 738	189 086	5.2
Selenium	kg	13 940	360 641	3.9	14 021	353 464	4.0	14 570	430 425	3.4
Silver	kg	217 613	1 197 072	18.2	312 905	1 087 989	28.8	331 245	1 374 946	24.1
Tellurium	kg	x	19 470	..	x	20 490	..	x	13 164	..
Tin	t	3 966	120	3 305.0	3 655	x	..	4 004	x	
Tungsten (W content)	kg	707 271	4 030 574	17.5	647 139	2 469 990	26.2	764 756	x	
Zinc	t	123 256	1 049 275	11.7	126 115r	988 173	12.8	131 137	1 157 936	11.3
Nonmetals										
Barite	t	59 284	71 049	83.4	22 701	40 335	56.3	15 832	42 103	37.6
Feldspar	t	2 014	-	..	2 248	-	..	2 340	-	..
Fluorspar	t	151 091	x	..	147 077r	x	..	179 595	x	..
Mica	kg	3 105	x	..	3 249r	x	..	4 791	x	..
Nepheline syenite	t	81 530	467 186	17.5	94 404	467 491	20.2	99 651	506 415	19.7
Phosphate rock	t	2 738 387	-	..	2 356 892	-	..	2 062 710	-	..
Potash (K_2O)	t	296 810	6 661 077	4.5	315 975	6 752 709	4.7	288 977	7 668 384	3.8
Sodium sulphate	t	241 143	366 217	65.8	228 360	370 726	61.6	188 626	342 076	55.1
Sulphur	t	1 110 683	8 924 522	12.4	1 094 147r	7 724 006	14.2r	986 443	6 531 940	15.1
Talc, etc	t	64 774	126 860	51.1	65 370r	123 037	53.1r	65 953	136 418	48.3
Fuels										
Coal	000 t	48 656r	60 436r	80.5r	44 558r	57 811r	77.1r	50 144	61 212	81.9
Natural gas[3]	million m^3	50 164	84 344r	59.5r	48 084	71 896	66.9	45 997	78 267	58.8
Crude oil[4]	000 m^3	79 808	85 564r	93.3r	78 205r	85 468r	91.5r	81 811	89 140	91.8

[1] Consumption defined as producers' domestic shipments of refined metal [2] Consumption includes primary and secondary refined metal [3] Consumption defined as domestic sales
[4] Consumption defined as refinery receipts
r Revised, - Nil, .. Not applicable, x Confidential
Note Unless otherwise stated, consumption refers to reported consumption of refined metals or nonmetallic minerals by consumers. Production of metals, in most cases, refers to production in all forms, and includes the recoverable content of ores, concentrates, matte, etc. and metal content of primary products recoverable at domestic smelters and refineries. Production of nonmetals refers to producers' shipments. For fuels, production is equivalent to actual output less waste.

TABLE 29. CANADA, DOMESTIC CONSUMPTION OF PRINCIPAL REFINED METALS IN RELATION TO REFINERY PRODUCTION[1], 1981-87

	Unit of Measure	1981	1982	1983	1984	1985	1986	1987
Aluminum								
Domestic consumption[2]	t	336 989	273 523	332 389	379 249	346 033	393 270[r]	421 392
Production	t	1 115 691	1 064 795	1 091 213	1 221 985	1 282 316	1 355 161	1 540 439
Consumption of production	%	30.2	25.7	30.5	31.0	27.0	29.0[r]	27.4
Copper								
Domestic consumption[3]	t	216 759	130 559	170 443	205 476	203 335	204 685	215 677
Production	t	476 655	337 780	464 333	504 262	499 626	493 445	491 178
Consumption of production	%	45.5	38.7	36.7	40.7	40.7	41.5	43.9
Lead								
Domestic consumption[4]	t	110 931	103 056	88 579	111 642	104 447[r]	94 680[r]	102 894
Production	t	168 450	174 310	178 043	174 987	173 220	169 934	139 479
Consumption of production	%	65.9	59.1	49.8	63.8	60.3[r]	55.7[r]	73.8
Zinc								
Domestic consumption[4]	t	113 061	100 233	116 257	119 573	123 256	126 115[r]	131 137
Production	t	618 650	511 870	617 033	682 976	692 406	570 981	610 474
Consumption of production	%	18.3	19.6	18.8[r]	17.5	17.8	22.1	21.5

[1] Production of refined metal from all sources, including metal derived from secondary materials at primary refineries. [2] Consumption of primary refined metal, reported by consumers. [3] Producers' domestic shipments of refined metal. [4] Consumption of primary and secondary refined metal, reported by consumers.
[r] Revised.

TABLE 30. AVERAGE ANNUAL PRICES[1] OF SELECTED MINERALS, 1981-87[2]

	Unit of Measure	1981	1982	1983	1984	1985	1986	1987
Aluminum, London Metal Exchange	¢/lb	57 274	44 966	65 342	56 526	47 850	52 179	71 004
Antimony, New York dealer	$/lb	1 355	1 072	0 913	1 512	1 311	1 219	1 116
Asbestos, No. 4T cement fibre	C$/t	850 000	876 000	1 083 000	1 083 000	1 083 000	1 083 000	1 083 000
Bismuth, New York dealer	$/lb	2 215	1 533	1 653	4 132	4 932	3 017	3 629
Cadmium, U.S. producer	$/lb	1 927	1 113	1 129	1 693	1 208	1 248	1 988
Calcium, metal crowns (Producer Price List)	$/lb	2 831	3 050	3 050	3 099	3 504	3 920	3 850
Chrome, U.S. metal, 9% carbon	$/lb	4 450	4 450	4 450	4 450	4 450	3 021	2 700
Cobalt, metal, shot/cathode/250 kg	$/lb	21 429[5]	12 500	12 500	12 417	11 700	11 242	7 000
Columbium, pyrochlore	$/lb	3 250	3 250	3 250	3 250	3 209	2 600	3 250
Copper, electrolytic cathode, COMEX	¢/lb	78 655	65 820	71 902	61 320	60 988	61 649	77 837
Gold, London[3]	C$/troy oz	551 178	465 102	520 792	466 781	433 227	510 628	592 011
Iridium, Impala producer	$/troy oz	600 000	600 000	600 000	600 000	600 000	600 000	513 750
Iron ore, taconite pellets	¢/ltu	80 073	80 500	80 500	80 500	80 500	80 500	77 548
Lead, producer	C¢/lb	44 520	32 887	26 770	33 517	26 179	30 885	47 985
Magnesium, U.S. primary ingot (Producer Price List)	$/lb	1 303	1 340	1 365	1 455	1 480	1 530	1 530
Manganese, U.S. metal, regular	¢/lb	70 000	86 274	67 583	73 542	80 000	79 450	80 687
Mercury, New York dealer	$/flask (76 lb.)	413 885	370 934	322 443	314 381	310 957	232 785	295 503
Molybdenum, dealer, oxide	$/lb	6 400	4 100	3 635	3 557	3 247	2 871	2 899
Nickel, major producer, cathode	$/lb	3 429	3 200	3 200	3 200	3 200	3 200	3 200
Osmium, New York dealer	$/troy oz	130 000	130 000	133 113	466 479	913 125	698 854	632 458
Palladium, Impala producer	$/troy oz	129 500	110 000	130 000	146 667	126 905	130 595	150 000
Platinum, Impala producer	$/troy oz	475 000	475 000	475 000	475 000	475 000	519 147	600 000
Potash, K_2O, coarse, major producer, 60% contained	$/st	72 480	72 480	71 500	65 000	55 729	46 750	43 500
Rhodium, Impala producer	$/troy oz	639 583	600 000	600 000	627 500	892 708	1 194 583	1 240 000
Ruthenium, New York dealer	$/troy oz	32 212	25 615	28 529	104 183	100 269	73 423	69 796
Selenium, New York dealer	$/lb	4 115	3 766	3 722	8 995	7 248	5 596	6 479
Silver, Handy & Harman, Toronto	C$/troy oz	12 617	9 831	14 154	10 828	8 674	7 862	9 593
Sulphur elemental, North American deliveries	C$/t	60 330	68 300	60 170	69 222	100 775	107 959[r]	88 234
Tantalum, tantalite ore, spot	$/lb	63 292	31 540	23 146	29 438	26 292	18 008	20 542
Tellurium, major producer, slab	$/lb	14 000	10 000	9 000	11 000	11 000	10 000	10 006
Tin, New York dealer	$/lb	6 484	5 869	6 013	5 678	5 279[r]	2 941	3 156
Titanium, slag	$/lt	135 000	150 000	150 000	150 000	150 000	150 000	150 000
Tungsten, London Metal Bulletin - ore	$/mtu	141 556[r]	103 992[r]	79 029[r]	79 146[r]	64 925[r]	42 554[r]	44 492
Uranium, U_3O_8[4]	C$/lb	42 311	44 234	38 500	34 600	35 380	34 000[r]	30 000
Vanadium, pentoxide, metallurgical	$/lb	3 250	3 350	3 350	3 350	3 350	3 350	3 350
Zinc, special high grade	C¢/lb	54 240	49 167	52 632	63 823	56 876	55 129	57 794

---

[1] Prices, except where noted, are in United States currency. [2] Sources: Alberta Energy Resource Industries Monthly Statistics, Engineering and Mining Journal, Metals Week, Northern Miner and Mineral Commodity Summaries. [3] Average afternoon fixings of London bullion dealers, converted to Canadian dollars. [4] From EMR publications on assessment of Canada's uranium supply and demand. [5] Seven-month average.
[r] Revised.

TABLE 31. CANADIAN AVERAGE ANNUAL PRICES OF SELECTED MINERALS, 1981-87[1]

	Unit of Measure	1981	1982	1983	1984	1985	1986	1987
Aluminum, London Metal Exchange	$/kg	1 514	1 223	1 775	1 614	1 440	1 598	2 073
Antimony, New York dealer	$/kg	3 582	2 917	2 481	4 316	3 947	3 734	3 262
Asbestos, No. 4T cement fibre	$/t	936 964	965 625	1 193 800	1 193 800	1 083 000[r]	1 083 000[r]	1 083 000
Bismuth, New York dealer	$/kg	5 855	4 171	4 491	11 795	14 847	9 241	10 609
Cadmium, U.S. producer	$/kg	5 094	3 028	3 067	4 833	3 637	3 823	5 812
Calcium, metal crowns (Producer Price List)	$/kg	7 483	8 298	8 287	8 846	10 549	12 008	11 255
Chrome, U.S. metal, 9% carbon	$/kg	11 763	12 107	12 090	12 703	13 396	9 253	7 893
Cobalt, metal, shot/cathode/250 kg	$/kg	56 610[4]	34 009	33 961	35 446	35 222	34 436	20 463
Columbium, pyrochlore	$/kg	8 591	8 842	8 830	9 278	9 660	7 964	9 501
Copper, electrolytic cathode, COMEX	$/kg	2 079	1 791	1 953	1 750	1 836	1 888	2 275
Gold, London[2]	$/g	17 721	14 953	16 744	15 007	13 929	16 417	19 034
Iridium, Impala producer	$/g	23 129	23 806	23 773	24 978	26 341	26 802	21 902
Iron ore, taconite pellets	¢/mtu	94 490	97 776	97 638	102 588	108 187	110 082	101 204
Lead, producer	¢/kg	98 150	72 503	59 018	73 892	57 715	68 090	105 789
Magnesium, U.S. primary ingot (Producer Price List)	$/kg	3 443	3 646	3 709	4 154	4 455	4 687	4 473
Manganese, U.S. metal, regular	$/kg	1 850	2 347	1 836	2 099	2 408	2 434	2 359
Mercury, New York dealer	$/kg	14 395	13 279	11 527	11 808	12 317	9 382	11 366
Molybdenum, dealer, oxide	$/kg	16 917	11 155	9 876	10 154	9 775	8 794	8 475
Nickel, major producer, cathode	$/kg	9 064	8 706	8 695	9 136	9 633	9 802	9 355
Osmium, New York dealer	$/g	5 011	5 158	5 274	19 420	40 088	31 218	26 963
Palladium, Impala producer	$/g	4 992	4 364	5 151	6 106	5 571	5 834	6 395
Platinum, Impala producer	$/g	18 310	18 847	18 820	19 774	20 853	23 191	25 579
Potash, K_2O, coarse, major producer, 60% contained	$/t	95 793	98 599	97 128	92 775	83 884	71 601	63 582
Rhodium, Impala producer	$/g	24 655	23 806	23 773	26 123	39 192	53 363	52 863
Ruthenium, New York dealer	$/g	1 242	1 016	1 130	4 337	4 402	3 280	2 976
Selenium, New York dealer	$/kg	10 877	10 246	10 112	25 677	21 820	17 141	18 940
Silver, Handy & Harman, Toronto	$/kg	405 646	316 074	455 062	348 140	269 791	252 769	308 422
Sulphur elemental, North American deliveries	$/t	60 330	68 300	60 170	69 222	100 775	107 959[r]	88 234
Tantalum, tantalite ore, spot	$/kg	167 300	85 811	62 885	84 034	79 150	55 161	60 050
Tellurium, major producer, slab	$/kg	37 006	27 207	24 452	31 401	33 115	30 631	29 250
Tin, New York dealer	$/kg	17 139	15 968	16 337	16 209	15 832[r]	9 009	9 226
Titanium, slag	$/t	159 306	182 191	181 933	194 225	201 591	205 121	195 757
Tungsten, London Metal Bulletin - ore	$/mtu	169 723	128 336	97 392	102 481	88 656	59 125	58 996
Uranium, U[3]	$/kg	110 000	115 000	100 000	90 000	92 000	89 000	79 000
Vanadium, pentoxide, metallurgical	$/kg	8 591	9 114	9 102	9 564	10 085[r]	10 262[r]	8 993
Zinc, special high grade	$/kg	1 196	1 084	1 160	1 407	1 254	1 215	1 274

---

[1] Sources: Alberta Energy Resource Industries Monthly Statistics, Engineering and Mining Journal, Metals Week, Northern Miner. [2] Average afternoon fixings of London bullion dealers, converted to Canadian dollars. [3] From EMR publications on assessment of Canada's uranium supply and demand. [4] Seven-month average.
[r] Revised.

TABLE 32. CANADA, MINERAL PRODUCTS INDUSTRIES, SELLING PRICE INDEXES,1981-87

	1981	1982	1983	1984	1985	1986	1987p
Iron and steel products industries							
Ferroalloy and steel foundries	100.0	104.3	104.1	110.5	113.3	114.7	113.3
Iron foundries	100.0	107.4	109.0	112.2	116.6	119.8	122.0
Primary steel industries	100.0	108.7	109.9	113.5	115.7	116.9	118.1
Steel pipe and tube mills	100.0	109.8	108.9	111.0	112.1	112.4	112.8
Nonferrous primary metal products industries							
Aluminum rolling, casting and extruding	100.0	99.9	103.6	116.2	111.2	114.4	117.0
Copper and alloy, rolling, casting and extruding	100.0	93.4	99.2	91.4	93.0	95.9	108.5
Jewellery and silverware manufacturers	100.0	88.6	99.9	90.6	87.7	94.9	99.8
Metal rolling, casting and extruding, n.e.s.	100.0	96.6	99.7	106.6	100.9	102.3	108.6
Nonferrous metal smelting and refining industries	100.0	90.6	95.6	98.1	91.7	95.2	106.5
Nonmetallic mineral products industries							
Agricultural chemicals industries	100.0	102.5	100.2	103.8	104.2	101.7	102.2
Cement manufacturers	100.0	117.9	123.7	128.0	133.9	137.3	138.4
Clay products from domestic clay	100.0	112.8	120.5	130.7	143.0	152.6	164.4
Clay products from imported clay	100.0	110.4	115.5	118.1	121.5	128.1	135.2
Concrete products manufacturers	100.0	111.2	115.0	113.8	114.0	120.5	126.4
Glass and glass products manufacturers	100.0	109.4	114.5	119.0	121.1	126.0	130.8
Nonmetallic mineral insulating materials industries	100.0	110.6	112.7	113.4	120.8	121.8	127.3
Petroleum and coal products industries	100.0	115.7	121.8	127.1	133.5	107.2	101.8
Fabricated metal products industries							
Agricultural implements industry	100.0	112.5	119.7	125.3	130.3	133.3	135.7
Fabricated structural metal products	100.0	107.8	108.5	110.8	115.3	118.0	119.9
Hardware, tool and cutlery manufacturers	100.0	111.6	115.7	121.6	128.0	132.5	137.5
Heating equipment manufacturers	100.0	111.6	117.5	121.9	127.2	129.6	132.8
Other metal fabricating industries	100.0	107.1	109.5	114.6	119.1	123.5	126.3
Power boiler and heat exchanger industry	100.0	106.0	110.7	114.2	120.0	130.0	141.5
Stamped pressed and coated metal products	100.0	107.1	112.5	115.8	118.4	123.2	127.0
Wire and wire products manufacturers	100.0	106.7	107.2	113.0	115.5	116.4	118.0

p Preliminary; n.e.s. Not elsewhere specified.

TABLE 33. CANADA, SELLING PRICE INDEXES OF MINERAL RAW MATERIALS,1981-87

	1981	1982	1983	1984	1985	1986	1987p
Metallic materials							
Copper concentrates	100.0	88.0	92.4	80.8	86.6	89.5	106.3
Iron ore	100.0	103.5	105.2	109.5	114.0	115.5	111.4
Lead concentrates	100.0	70.6	57.5	73.1	56.7	67.7	106.2
Nickel concentrates	100.0	91.3	84.5	92.8	99.4	87.2	97.0
Other base metals, n.e.s.	100.0	90.5	95.3	104.8	94.8	96.8	103.6
Precious metals	100.0	82.5	99.0	84.9	77.2	86.6	99.2
Gold ingots	100.0	83.1	98.0	85.0	78.2	88.1	100.5
Platinum	100.0	76.5	99.6	87.5	74.1	119.3	139.0
Silver	100.0	75.4	111.2	82.1	65.8	59.8	72.9
Radioactive concentrates	100.0	110.3	98.5	95.1	91.9	91.1	89.2
Zinc concentrates	100.0	89.9	96.3	118.4	105.0	101.7	108.5
Nonmetal materials							
Asbestos	100.0	100.7	110.9	110.4	108.0	107.7	107.8
Other nonmetallic materials, n.e.s.	100.0	110.5	110.1	114.3	116.0	117.5	117.7
Potash (muriate)	100.0	104.6	91.8	99.5	93.5	92.0	99.0
Sand and gravel	100.0	109.2	108.8	108.2	109.4	112.1	117.3
Silica sand	100.0	110.5	117.2	114.6	118.4	122.1	122.6
Stone	100.0	112.8	123.6	127.5	133.8	138.9	143.4
- building	100.0	112.0	123.2	127.6	132.9	136.5	141.3
- crushed	100.0	114.9	127.6	134.6	143.3	151.0	157.3
- other	100.0	112.0	123.2	127.6	132.9	136.5	141.3
Sulphur	100.0	112.8	98.9	114.4	167.2	179.1	147.4
Mineral fuels							
Coal, thermal	100.0	110.3	111.0	118.6	119.5	119.3	120.4
Natural gas	100.0	127.6	134.3	131.4	131.6	129.2	125.0
Oil, crude	100.0	120.6	130.0	131.8	138.9	80.1	88.7

p Preliminary; n.e.s. Not elsewhere specified.

TABLE 34. CANADA, PRINCIPAL STATISTICS OF THE MINERAL INDUSTRY[1], 1986

	Mining Activity								Total Activity[2]		
	Production and Related Workers				Costs						
	Establishments	Employees	Person-hours Paid	Wages	Fuel and Electricity	Materials and Supplies	Value of Production	Value Added	Employees	Salaries and Wages	Value Added
	(number)	(number)	(000)	($000)	($000)	($000)	($000)	($000)	(number)	($000)	($000)
Metals											
Gold	46	6 598	13 976	251 446	72 598	340 459	1 388 382	975 326	8 562	331 166	975 348
Silver-lead-zinc	13	2 979	6 318	110 887	61 444	533 641	941 015	345 930	4 162	165 203	332 216
Nickel-copper-zinc	25	15 362	31 909	544 364	210 589	1 448 074	3 348 156	1 689 493	20 616	764 867	1 712 888
Uranium	5	4 586	9 742	192 631	60 171	175 172	1 044 537	809 195	5 608	237 234	801 962
Iron	8	4 578	9 853	179 432	180 345	399 535	1 297 562	717 682	6 379	257 593	713 780
Miscellaneous metal mines	7	838	1 795	30 197	12 576	36 549	105 044	55 919	1 160	42 294	54 508
Total	104	34 941	73 593	1 308 957	597 723	2 933 430	8 124 696	4 593 545	46 487	1 798 357	4 590 702
Industrials											
Asbestos	5	2 117	4 538	62 744	32 779	48 132	236 982	156 071	2 766	87 444	157 138
Peat	61	1 200	2 683	21 905	4 905	21 135	95 057	69 016	1 468	28 632	74 563
Gypsum	10	686	1 678	17 390	6 888	20 903	84 776	56 985	990	28 478	56 579
Potash	11	3 038	6 426	96 246	108 181	94 403	598 557	395 974	4 315	149 294	396 354
Miscellaneous nonmetals	49	2 026	4 476	66 257	33 827	56 344	378 389	288 218	2 837	93 643	289 082
Sand and gravel	115	1 300	2 985	38 020	23 764	66 366	278 473	188 343	2 260	65 331	220 026
Stone	123	2 009	4 573	58 477	29 670	85 008	384 501	269 823	2 627	77 454	277 604
Total	374	12 376	27 359	361 039	240 014	392 291	2 056 735	1 424 430	17 263	530 276	1 471 346
Fuels											
Coal	28	8 225	16 218	334 980	114 117	329 902	1 553 515	1 109 496	10 745	455 392	1 110 434
Oil, crude and natural gas	1 002	8 813	17 871	362 514	288 518	994 145	16 043 395	14 760 732	36 966	1 709 228	15 044 258
Total	1 030	17 038	34 089	697 494	402 635	1 324 047	17 596 910	15 870 228	47 711	2 164 620	16 154 692
Total mineral industry	1 508	64 355	135 041	2 367 490	1 240 372	4 649 768	27 778 341	21 888 203	111 461	4 493 253	22 216 740

[1] Cement manufacturing, lime manufacturing, clay and clay products (domestic clays) are included in the mineral manufacturing industry [2] Total activity includes sales and head offices
Note: Totals may not add due to rounding

TABLE 35. CANADA, PRINCIPAL STATISTICS OF THE MINERAL MANUFACTURING INDUSTRIES, 1986

	Mineral Manufacturing Activity								Total Activity[1]		
		Production and Related Workers			Costs						
	Establishments	Employees	Person-hours Paid	Wages	Fuel and Electricity	Materials and Supplies	Value of Shipments	Value Added	Employees	Salaries and Wages	Value Added
	(number)	(number)	(000)	($000)	($000)	($000)	($000)	($000)	(number)	($000)	($000)
Primary metal industries											
Primary steel	58	35 193	76 001	1 258 271	501 083	4 161 518	7 753 946	2 990 359	46 461	1 732 803	3 001 589
Steel pipe and tube	38	3 563	7 857	113 820	18 982	622 518	985 473	329 316	4 829	162 693	330 955
Iron foundries	100	6 345	13 803	181 646	40 890	269 340	812 837	510 255	7 547	228 419	510 681
Smelting and refining	34	20 233	40 523	720 306	408 615	1 892 980	4 744 013	2 379 504	29 058	1 115 267	2 372 789
Aluminum rolling, casting and extruding	71	4 938	10 893	153 133	37 571	946 194	1 399 970	425 073	6 200	205 352	424 927
Copper and alloy rolling, casting and extruding	38	2 626	5 473	66 423	14 414	357 731	521 587	147 486	3 059	83 378	144 012
Metal rolling, casting and extruding, n.e.s.	104	5 251	11 595	139 859	28 527	471 775	891 139	397 298	6 357	178 595	397 072
Total	443	78 149	166 145	2 633 458	1 050 082	8 722 056	17 108 965	7 179 291	103 511	3 706 507	7 182 025
Nonmetallic mineral products industries											
Cement	24	2 205	4 919	85 531	160 698	173 174	831 734	495 505	3 514	136 166	500 220
Lime	14	593	1 271	20 773	42 532	24 567	144 365	76 755	778	28 081	78 025
Concrete pipe	51	1 402	2 994	36 203	5 923	81 782	211 158	121 680	1 706	48 621	122 022
Structural concrete products	61	2 187	4 684	60 506	5 728	102 286	274 693	165 569	2 697	79 150	164 283
Other concrete products	297	4 252	8 738	89 540	15 834	182 752	426 955	230 798	4 771	109 125	235 853
Ready-mix concrete	595	8 779	18 414	241 196	53 971	825 897	1 488 664	609 609	10 422	294 410	626 340
Gypsum products	28	1 568	3 367	44 545	37 801	212 318	522 556	272 930	2 195	65 837	283 901
Clay products (domestic)	36	1 210	2 642	32 359	28 940	26 311	182 007	124 777	1 605	46 710	129 418
Clay products (imported)	56	1 806	3 737	40 066	8 380	41 410	147 035	97 288	2 165	49 930	98 625
Primary glass and glass containers	18	5 863	12 329	171 527	65 064	190 242	736 912	482 326	7 722	241 583	482 438
Glass products	165	4 852	9 890	117 548	15 346	324 266	632 933	290 805	5 726	147 903	294 876
Abrasives	30	1 347	2 724	33 943	32 342	99 694	227 745	96 953	1 827	50 563	100 513
Refractory products	25	1 035	2 175	26 836	8 080	79 390	179 184	93 707	1 616	44 820	99 872
Mineral insulating products	46	2 181	4 680	62 477	33 687	153 706	353 846	165 289	3 464	109 231	237 702
Other nonmetallic mineral products	155	2 113	4 315	43 653	9 774	86 245	210 580	117 260	2 447	54 272	124 530
Total	1 601	41 393	86 879	1 106 703	524 100	2 604 040	6 570 367	3 441 251	52 655	1 306 402	3 578 618
Petroleum and coal products industries											
Petroleum refining products	31	5 227	11 673	232 528	300 134	12 395 312	15 145 368	1 722 197	13 287	608 838	1 724 990
Lubricating oils and greases	35	603	1 345	18 449	5 575	207 881	295 038	80 109	1 001	31 742	82 467
Other petroleum and coal products	60	529	1 104	14 179	10 539	195 098	315 959	98 786	778	23 840	98 856
Total	126	6 359	14 122	265 156	316 248	12 798 291	15 756 365	1 901 092	15 066	664 420	1 906 313
Total, mineral manufacturing industries	2 170	125 901	267 146	4 005 317	1 890 430	24 124 387	39 435 697	12 521 634	171 232	5 877 329	12 666 956

1 Total activity includes sales and head offices

n.e.s. Not elsewhere specified

Note: Totals may not add due to rounding.

TABLE 36. CANADA, PRINCIPAL STATISTICS OF THE MINERAL INDUSTRY[1] BY REGION, 1986

		Mines, Quarries and Oil Well Activity									
		Production and Related Workers			Costs				Total Activity[2]		
	Establishments	Employees	Person-hours Paid	Wages	Fuel and Electricity	Materials and Supplies	Value of Production	Value Added	Employees	Salaries and Wages	Value Added
	(number)	(number)	(000)	($000)	($000)	($000)	($000)	($000)	(number)	($000)	($000)
Atlantic Provinces[3]	217	7 463	15 869	235 002	129 564	470 478	1 306 911	706 872	9 834	326 882	721 770
Quebec	189	10 372	22 164	350 893	176 973	583 752	1 792 604	1 031 880	14 303	500 736	1 051 072
Ontario	144	18 035	38 160	650 728	211 961	1 206 745	3 867 128	2 448 421	24 602	916 318	2 486 742
Prairie Provinces	622	17 030	34 914	639 232	477 560	1 430 890	17 205 859	15 297 407	47 604	2 070 719	15 482 925
British Columbia[4]	186	9 193	18 697	383 371	188 670	710 025	2 795 474	1 896 779	11 854	521 275	1 900 991
Yukon and Northwest Territories[5]	150	2 262	5 238	108 262	55 644	247 879	810 364	506 841	3 264	157 324	573 241
Canada	1 508	64 355	135 042	2 367 488	1 240 372	4 649 769	27 778 340	21 888 200	111 461	4 493 254	22 216 741

[1] Cement manufacturing, lime manufacturing, clay and clay products (domestic clays) are included in the mineral manufacturing industry [2] Total activity includes sales and head offices [3] Includes eastern Canada offshore [4] Includes western Canada offshore [5] Includes Arctic Islands and offshore

Note Totals may not add due to rounding.

TABLE 37. CANADA, PRINCIPAL STATISTICS OF THE MINERAL MANUFACTURING INDUSTRY BY REGION, 1985

		Mineral, Manufacturing Activity							Total Activity[1]		
		Production and Related Workers			Costs						
	Establishments	Employees	Person-hours Paid	Wages	Fuel and Electricity	Materials and Supplies	Value of Shipments	Value Added	Employees	Salaries and Wages	Value Added
	(number)	(number)	(000)	($000)	($000)	($000)	($000)	($000)	(number)	($000)	($000)
Atlantic Provinces	132	x	x	x	x	x	x	x	x	x	x
Quebec	506	30 578	61 736	939 562	621 137	7 711 268	11 536 465	3 079 314	42 081	1 398 565	3 081 899
Ontario	837	71 362	154 091	2 237 325	958 653	13 857 241	21 195 147	6 358 094	98 549	3 311 379	6 457 471
Prairie Provinces	367	x	x	x	x	x	x	x	x	x	x
British Columbia	245	x	x	x	x	x	x	x	x	x	x
Yukon and Northwest Territories	1	x	x	x	x	x	x	x	x	x	x
Canada	2 088	126 188	267 242	3 928 446	1 992 719	32 301 083	47 270 927	12 667 645	174 152	5 828 819	12 809 320

[1] Total activity includes sales and head offices.

x Confidential, included in Canadian total.

TABLE 38. CANADA, PRINCIPAL STATISTICS OF THE MINERAL INDUSTRY[1], 1980–86

	Mines, Quarries and Oil Well Activity										
		Production and Related Workers			Costs				Total Activity[2]		
	Establishments	Employees	Person-hours Paid	Wages	Fuel and Electricity	Materials and Supplies	Value of Production	Value Added	Employees	Salaries and Wages	Value Added
	(number)	(number)	(000)	($000)	($000)	($000)	($000)	($000)	(number)	($000)	($000)
1980	1 322	80 066	166 427	1 779 388	706 406	3 802 062	27 566 272	23 057 804	126 422	2 979 470	23 252 708
1981	1 361	81 136	167 307	2 053 760	888 554	4 266 637	28 204 485	23 049 295	129 251	3 439 945	23 091 447
1982	1 247[r]	74 178[r]	141 070[r]	2 008 439[r]	956 296	3 768 771	29 101 618	24 376 549	123 486	3 648 004	24 427 308[r]
1983	1 407	66 629	131 406	1 963 773	1 022 417	3 756 625	32 771 401	27 992 357	113 831	3 687 911[r]	28 012 167
1984	1 381	69 650[r]	140 567[r]	2 295 256[r]	1 204 008[r]	4 290 972	37 976 019	32 481 039	115 790	4 106 049	32 545 525[r]
1985	1 386	67 308[r]	140 780[r]	2 357 868[r]	1 264 619	4 442 358	38 127 807	34 420 830	117 161[r]	4 413 258[r]	32 495 098
1986	1 508	64 355	135 041	2 367 490	1 240 372	4 649 768	27 778 341	21 888 203	111 461	4 493 253	22 216 740

[1] Cement manufacturing, lime manufacturing, clay and clay products (domestic clays) are included in the mineral manufacturing industry [2] Includes sales and head offices
[r] Revised

TABLE 39. CANADA, PRINCIPAL STATISTICS OF THE MINERAL MANUFACTURING INDUSTRIES, 1980–86

	Mineral Manufacturing Activity										
		Production and Related Workers			Costs				Total Activity[1]		
	Establishments	Employees	Person-hours Paid	Wages	Fuel and Electricity	Materials and Supplies	Value of Production	Value Added	Employees	Salaries and Wages	Value Added
	(number)	(number)	(000)	($000)	($000)	($000)	($000)	($000)	(number)	($000)	($000)
1980	2 143	146 606	308 312	2 927 363	1 272 902	22 045 572	32 177 335	9 417 966	204 872	4 386 065	9 599 968
1981	2 124	140 914	293 781	3 187 784	1 560 453	28 125 138	39 495 229	10 862 006	203 051	4 932 893	11 062 937
1982	2 106	124 304	256 900	3 175 123	1 537 247	27 801 486	38 496 873	9 078 253	182 665	5 070 760	9 256 207
1983	2 143	119 093	246 101	3 281 473	1 701 521	29 177 081	41 675 029	10 580 670	171 719	5 128 268	10 759 467
1984	2 182	124 147	262 222	3 710 851	1 901 089	31 588 420	45 014 678	12 147 253	175 107	5 605 097	12 264 066
1985	2 088	126 188	267 242	3 928 446	1 992 719	32 301 083	47 270 927	12 667 645	174 152	5 828 819	12 809 320
1986	2 170	125 901	267 146	4 005 317	1 890 430	24 124 387	39 435 697	12 521 634	171 232	5 877 329	12 666 956

[1] Total activity includes sales and head offices

TABLE 40. CANADA, CONSUMPTION OF FUEL AND ELECTRICITY IN THE MINERAL INDUSTRY[1], 1986

	Unit	Metals	Industrials[2]	Fuels	Total
Coal	000 t	285	–	–	285
	$000	18 967	–	–	18 967
Gasoline	000 litres	20 514	16 899	11 366	48 779
	$000	8 558	6 782	3 934	19 274
Fuel oil, kerosene, diesel oil	000 litres	784 433	233 872	208 540	1 226 845
	$000	183 559	69 094	53 649	306 302
Liquefied petroleum gas	000 litres	98 914	10 779	17 646	127 339
	$000	19 579	2 687	3 012	25 278
Natural gas	000 m^3	251 590	655 133	111 122	1 017 845
	$000	36 416	74 879	12 831	124 126
Other fuels[3]	$000	9 815	–	–	9 815
Total value of fuels	$000	276 894	153 442	73 426	503 762
Electricity purchased	million kWh	12 066	2 107	7 183	21 356
	$000	320 828	86 571	329 208	736 607
Total value of fuels and electricity purchased, all reporting companies	$000	597 722	240 013	402 634	1 240 369

[1] Cement manufacturing, lime manufacturing, clay and clay products (domestic clays) are included in the mineral manufacturing industry. [2] Includes structural materials. [3] Includes wood, manufactured gas, steam purchased and other miscellaneous fuels.
– Nil.
Note: Totals may not add due to rounding.

TABLE 41. CANADA, CONSUMPTION OF FUEL AND ELECTRICITY IN THE MINERAL MANUFACTURING INDUSTRIES, 1985

	Primary Metal Industries	Nonmetallic Mineral Products Industries	Petroleum and Coal Products Industries	Total
		($000)		
Coal and coke	47 022	56 224	–	103 246
Gasoline	5 759	8 304	1 393	15 456
Fuel oil, kerosene, diesel oil	124 740	71 594	2 709	199 043
Liquefied petroleum gas	9 857	3 585	5 563	19 005
Natural gas	374 553	203 069	240 194	817 816
Other fuels	13 935	38 096	8 886	60 917
Electricity purchased	512 526	152 967	111 744	777 236
Total value of fuels and electricity purchased	1 088 392	533 838	370 489	1 992 719

– Nil.
Note: Totals may not add due to rounding.

TABLE 42. CANADA, COST OF FUEL AND ELECTRICITY USED IN THE MINING INDUSTRY[1],1980-86

	Unit	1980	1981	1982	1983	1984	1985	1986
Metals								
Fuel	$000	220 052	293 979	275 205	270 098	331 231	337 445	276 894
Electricity purchased	million kWh	11 024	10 494	9 891	9 659	11 672	11 504	12 066
	$000	174 837	209 316	232 137	238 458	272 932	281 373	320 828
Total cost of fuel and electricity	$000	394 889	503 295	507 342[r]	508 556	604 163[r]	618 818	597 722
Industrials[2]								
Fuel	$000	112 672	142 169	143 393	157 872	169 486	165 665	153 442
Electricity purchased	million kWh	2 269	2 100	1 782	1 928	2 120	2 122	2 107
	$000	48 336	56 297	57 567	64 052	76 884	82 114	86 571
Total cost of fuel and electricity	$000	161 008	198 466	200 960	221 924	246 370	247 779	240 013
Fuels								
Fuel	$000	32 582	46 991	70 484	68 800	89 237	101 049	73 426
Electricity purchased	million kWh	3 504	3 740	5 780	4 958	5 840	6 569	7 183
	$000	117 927	139 802	176 911	223 136	264 233	296 973	329 208
Total cost of fuel and electricity	$000	150 509	186 793	247 395	291 936	353 470	398 022	402 634
Total mining industry								
Fuel	$000	365 306	483 139	489 082[r]	496 770	589 954[r]	604 159	503 762
Electricity purchased	million kWh	16 797	16 334	17 453	16 545[r]	19 632	20 195	21 356
	$000	341 100	405 415	466 615[r]	525 646	614 049	660 460	736 607
Total cost of fuel and electricity	$000	706 406	888 554	955 697[r]	1 022 416	1 204 003[r]	1 264 619	1 240 369

[1] Cement manufacturing, lime manufacturing, clay and clay products (domestic clays) are included in the mineral manufacturing industry. [2] Includes structural materials.

[r] Revised.

TABLE 43. CANADA, COST OF FUEL AND ELECTRICITY USED IN THE MINERAL MANUFACTURING INDUSTRY,1980-85

	Unit	1980	1981	1982	1983	1984	1985
Primary Metals							
Fuel	$000	421 426	538 175	526 073	555 381	605 177	575 867
Electricity purchased	million kWh	20 535	20 429	16 848	17 524	18 904	. .
	$000	316 884	357 186	345 614	396 632	463 357	512 526
Total cost of fuel and electricity	$000	738 317	895 361	871 687	952 014	1 068 535	1 088 392
Nonmetallic mineral products							
Fuel	$000	271 481	333 061	328 566	342 315	368 216	380 871
Electricity purchased	million kWh	4 633	4 573	3 973	3 983	4 439	. .
	$000	102 765	114 062	116 243	125 310	143 243	152 967
Total cost of fuel and electricity	$000	374 248	447 123	444 809	467 624	511 459	533 838
Petroleum and coal products							
Fuel	$000	88 311	137 463	134 303	187 624	221 369	258 745
Electricity purchased	million kWh	3 705	3 669	3 476	3 491	3 517	. .
	$000	72 186	80 517	86 448	94 259	99 727	111 744
Total cost of fuel and electricity	$000	160 498	217 980	220 751	281 883	321 095	370 489
Total mineral manufacturing industries							
Fuel	$000	781 218	1 008 699	988 942	1 085 391	1 194 762	1 215 483
Electricity purchased	million kWh	28 873	28 671	24 297	24 997	26 860	. .
	$000	491 834	551 765	548 305	616 201	706 327	777 236
Total cost of fuel and electricity	$000	1 273 063	1 560 464	1 537 247	1 701 521	1 901 089	1 992 719

. . Figures no longer available

TABLE 44. CANADA, EMPLOYMENT, SALARIES AND WAGES IN THE MINING INDUSTRY[1],1980-86

	Unit	1980	1981	1982	1983	1984	1985	1986
Metals								
Production and related workers	Number	47 592	49 586	44 261	37 270	39 181	36 618	34 941
Salaries and wages	$000	1 091 848	1 265 547	1 180 485	1 110 308	1 296 157	1 288 990	1 308 956
Annual average salary and wage	$	22 942	25 522	26 671	29 791	33 081	35 201	37 462
Administrative and office workers	Number	18 526	19 126	17 242	14 924	13 502	12 054	11 546
Salaries and wages	$000	504 316	585 120	585 249	533 517	518 644	487 398	489 402
Annual average salary and wage	$	27 222	30 593	33 943	35 749	38 412	40 435r	42 387
Total metals								
Employees	Number	66 118	68 712	61 503	52 194	52 683	48 672	46 487
Salaries and wages	$000	1 596 164r	1 850 667	1 765 734	1 643 825	1 814 801	1 776 388	1 798 358
Annual average salary and wage	$	24 141	26 934r	28 710	31 495	34 448r	36 497	38 685
Industrials								
Production and related workers	Number	16 645	15 666	12 848	12 768	13 008	12 535	12 376
Salaries and wages	$000	343 004	352 302	309 736	329 201r	356 828	354 460	361 039
Annual average salary and wage	$	20 607	22 488	24 108	25 783	27 431	28 278	29 173
Administrative and office workers	Number	4 795	4 908	4 323	3 805	4 250	4 380	4 887
Salaries and wages	$000	116 932	128 852	129 116	115 378r	138 012	148 090	169 237
Annual average salary and wage	$	24 386	26 253	29 867	30 323	32 473	33 811	34 630
Total industrials								
Employees	Number	21 440	20 574	17 171	16 573	17 258	16 915	17 263
Salaries and wages	$000	459 936	481 154	438 852	444 579r	494 840	502 550	530 276
Annual average salary and wage	$	21 452	23 387	25 558	26 825r	28 673	29 710	30 717
Fuels								
Production and related workers	Number	15 829	15 884	17 069r	16 591	17 461r	18 155r	17 038
Salaries and wages	$000	344 537	435 911	518 217r	524 264	642 271r	714 418r	697 494
Annual average salary and wage	$	21 766	27 443	30 360r	31 599	36 783r	39 351r	40 938
Administrative and office workers	Number	23 035	24 081	27 743r	28 473	28 388r	33 419r	30 673
Salaries and wages	$000	578 832	672 213	925 201r	1 075 245r	1 154 137r	1 419 903r	1 467 126
Annual average salary and wage	$	25 128	27 915	33 349r	37 764	40 656r	42 488r	47 831
Total fuels								
Employees	Number	38 864	39 965	44 812	45 064	45 849r	51 574r	47 711
Salaries and wages	$000	923 369	1 108 124	1 443 418	1 599 509r	1 796 408r	2 134 321r	2 164 620
Annual average salary and wage	$	23 759	27 727	32 211	35 494	39 181r	41 384r	45 369
Total mining								
Production and related workers	Number	80 066	81 136	74 178r	66 629	69 650r	67 308r	64 355
Salaries and wages	$000	1 779 389	2 053 760	2 008 438r	1 963 773r	2 295 256r	2 357 868r	2 367 489
Annual average salary and wage	$	22 224	25 313	27 076r	29 473	32 954r	35 031r	36 788
Administrative and office workers	Number	46 356	48 115	49 308r	47 202	46 140r	49 853r	47 106
Salaries and wages	$000	1 200 080	1 386 185	1 639 566r	1 724 140r	1 810 793r	2 055 391r	2 125 765
Annual average salary and wage	$	25 888	28 810	33 252r	36 527r	39 246r	41 229r	45 127
Total mining								
Employees	Number	126 422	129 251	123 486	113 831	115 790r	117 161r	111 461
Salaries and wages	$000	2 979 469	3 439 945	3 648 004	3 687 913r	4 106 049r	4 413 259r	4 493 254
Annual average salary and wage	$	23 568	26 614	29 542	32 398r	35 461r	37 668r	40 312

[1] Cement manufacturing, lime manufacturing, clay and clay products (domestic clays) are included in the mineral manufacturing industry.
r Revised.
Note: Totals may not add due to rounding.

TABLE 45. CANADA, EMPLOYMENT, SALARIES AND WAGES IN THE MINERAL MANUFACTURING INDUSTRIES,1980-86

	Unit	1980	1981	1982	1983	1984	1985	1986
Primary metal industries								
Production and related workers	Number	97 530	92 337	82 186	77 579	81 454	80 959[r]	78 149
Salaries and wages	$000	1 980 423	2 120 019	2 157 186	2 216 614	2 564 420	2 660 807	2 633 458
Annual average salary and wage	$	20 306	22 960	26 248	28 572	31 483	32 866	33 698
Administrative and office workers	Number	28 920	32 831	31 029	27 773	27 496	25 849	25 362
Salaries and wages	$000	787 022	938 790	1 010 847	964 429	1 033 620	1 047 040	1 073 049
Annual average salary and wage	$	27 214	28 595	32 577	34 725	37 592	40 506	42 309
Total primary metal industries								
Employees	Number	126 450	125 168	113 215	105 352	108 950	106 808	103 511
Salaries and wages	$000	2 767 445	3 058 809	3 168 033	3 181 043	3 598 040	3 707 847	3 706 507
Annual average salary and wage	$	21 886	24 438	27 982	30 194	33 025	34 715	35 808
Nonmetallic mineral products industries								
Production and related workers	Number	40 799	40 145	33 997	34 097	36 155	38 763	41 393
Salaries and wages	$000	743 254	818 566	751 915	800 755	883 604	1 001 780	1 106 703
Annual average salary and wage	$	18 217	20 390	22 117	23 485	24 439	25 844	26 736
Administrative and office workers	Number	15 287	15 124	13 952	13 353	12 738	11 842	11 262
Salaries and wages	$000	333 815	369 899	383 405	391 901	394 619	397 129	399 699
Annual average salary and wage	$	21 837	24 458	27 480	29 349	30 980	33 536	35 491
Total nonmetallic mineral products								
Employees	Number	56 086	55 269	47 949	47 450	48 893	50 605	52 655
Salaries and wages	$000	1 077 069	1 188 455	1 135 320	1 192 656	1 278 223	1 398 911	1 506 402
Annual average salary and wage	$	19 203	21 503	23 678	25 135	26 143	27 644	28 609
Petroleum and coal products industries								
Production and related workers	Number	8 277	8 432	8 121	7 417	6 538	6 436	6 359
Salaries and wages	$000	203 686	249 199	266 022	264 104	262 827	265 859	265 156
Annual average salary and wage	$	24 609	29 554	32 757	35 608	40 200	41 308	41 698
Administrative and office workers	Number	11 769	14 182	13 380	11 500	10 726	10 303	8 707
Salaries and wages	$000	337 865	436 430	501 385	490 465	466 006	456 202	399 264
Annual average salary and wage	$	28 708	30 773	37 473	42 649	43 446	44 279	45 856
Total petroleum and coal products								
Employees	Number	20 046	22 614	21 501	18 917	17 264	16 739	15 066
Salaries and wages	$000	541 551	685 629	767 407	754 569	728 833	722 061	664 420
Annual average salary and wage	$	27 015	30 319	35 692	39 888	42 217	43 136	44 101
Total mineral manufacturing								
Production and related workers	Number	146 606	140 914	124 304	119 093	124 147	126 158[r]	125 901
Salaries and wages	$000	2 927 363	3 187 784	3 175 123	3 281 473	3 710 851	3 928 446	4 005 317
Annual average salary and wage	$	19 968	22 622	25 543	27 554	29 891	31 139[r]	31 813
Administrative and office workers	Number	55 976	62 137	58 361[r]	52 626	50 960	47 994	45 331
Salaries and wages	$000	1 458 702	1 745 109	1 895 637	1 846 795	1 894 245[r]	1 900 371	1 872 012
Annual average salary and wage	$	26 059	28 085	32 481[r]	35 093	37 171	39 596[r]	41 297
Total mineral manufacturing industries								
Employees	Number	202 582	203 051	182 665	171 719	175 107	174 152	171 232
Salaries and wages	$000	4 386 065	4 932 903[r]	5 070 760	5 128 268	5 605 096[r]	5 828 817[r]	5 877 329
Annual average salary and wage	$	21 651	24 294	27 760	29 864	32 010	33 470	34 324

[r] Revised

TABLE 46. CANADA, NUMBER OF WAGE EARNERS EMPLOYED IN THE MINING INDUSTRY (SURFACE, UNDERGROUND AND MILL), 1980-86

	1980	1981	1982	1983	1984	1985	1986
Metals							
Surface	14 347	14 043	12 133	9 970	9 724	10 093	9 674
Underground	19 308	19 784	18 673	15 861	16 668	14 798	13 982
Mill	13 937	15 759	13 455	11 439	12 789	11 727	11 285
Total	47 592	49 586	44 261	37 270	39 181	36 618	34 941
Industrials							
Surface	6 510	6 015	4 833	4 951	4 948	4 921	5 396
Underground	2 550	2 606	2 055	2 192	2 487	2 337	2 112
Mill	7 585	7 045	5 960	5 625	5 573	5 277	4 868
Total	16 645	15 666	12 848	12 768	13 008	12 535	12 376
Fuels							
Surface	10 550	11 429	13 283^{r}	12 190	14 392^{r}	15 101^{r}	14 165^{e}
Underground	2 900	2 926	3 226	2 896	1 818	1 626	1 602^{e}
Mill	2 379	1 529	560^{r}	1 505	1 251	1 428	1 271
Total	15 829	15 884	17 069^{r}	16 591	17 461^{r}	18 155^{r}	17 038
Total Mining Industry							
Surface	31 407	31 487	30 249^{r}	27 111	29 064^{r}	30 115^{r}	29 235
Underground	24 758	25 316	23 954	20 949	20 973	18 761	17 696
Mill	23 901	24 333	19 975^{r}	18 569	19 613	18 432	17 424
Total	80 066	81 136	74 178^{r}	66 629	69 650^{r}	67 308^{r}	64 355

^{r} Revised; ^{e} Estimate.

Note: Totals may not add due to rounding.

TABLE 47. CANADA, MINE AND MILL WORKERS BY SEX, 1986

	Mine Workers				Mill Workers		Total	
	Underground		Surface					
	Male	Female	Male	Female	Male	Female	Male	Female
Metallic minerals								
Nickel–copper–zinc[1]	6 978	14	4 497	96	3 625	152	15 100	262
Gold	3 532	7	1 041	40	1 937	41	6 510	88
Iron ore	104	2	1 194	8	3 204	66	4 502	76
Uranium	1 922	11	1 828	35	717	73	4 467	119
Silver–lead–zinc	1 278	6	487	30	1 143	35	2 908	71
Miscellaneous metal mines[2]	128	–	415	3	277	15	820	18
Total	13 942	40	9 462	212	10 903	382	34 307	634
Industrial minerals								
Asbestos	45	–	816	3	1 203	50	2 064	53
Potash	1 425	9	82	1	1 487	34	2 994	44
Miscellaneous nonmetals[3]	470	–	419	10	1 096	31	1 985	41
Stone	5	–	1 804	14	184	2	1 993	16
Peat	–	–	582	17	580	21	1 162	38
Sand and gravel	–	–	1 192	14	94	–	1 286	14
Gypsum	158	–	441	1	86	–	685	1
Total	2 103	9	5 336	60	4 730	138	12 169	207
Fuels								
Coal	1 602e	–	5 261e	91e	1 243	28	8 106	119
Mining total	17 647	49	20 059	363	16 876	548	54 582	960

[1] Includes copper–zinc and nickel–copper mines. [2] Includes molybdenum mines. [3] Includes quartz mines and salt mines.
– Nil; e Estimate.

TABLE 48. CANADA, LABOUR COSTS FOR METAL MINES IN RELATION TO TONNES MINED, 1984–86

Type of Metal Mine	Number of Wage Earners	Total Wages	Average Annual Wage	Tonnage of Ore Mined	Average Annual Tonnes Mined per Wage Earner	Wage Cost per Tonne Mined
		($000)	($)	(kilotonnes)		($)
1984						
Uranium	3 885	139 466	35 899	7 608	1 958	18.33
Gold	4 800	161 233	33 590	11 225	2 339	14.36
Silver–lead–zinc	2 057	81 269	39 509	10 084	4 902	8.06
Miscellaneous metals[1]	519	17 088	32 925	3 627	6 988	4.71
Nickel–copper–zinc[2]	13 575	425 836	31 369	124 683	9 185	3.42
Iron ore	1 556	56 874	36 551	89 210	57 333	0.64
Total	26 392	881 766	33 410	246 437	9 338	3.58
1985						
Uranium	4 024	158 110	39 292	7 183	1 785	22.01
Gold	4 507	162 094	35 965	11 997	2 662	13.51
Silver–lead–zinc	1 982	73 202	36 933	9 970	5 030	7.34
Miscellaneous metals[1]	532	18 412	34 609	4 068	7 647	4.53
Nickel–copper–zinc[2]	12 335	415 630	33 695	117 169	9 499	3.55
Iron ore	1 511	58 147	38 482	94 588	62 600	0.61
Total	24 891	885 595	35 579	244 975	9 842	3.62
1986						
Uranium	3 796	161 248	42 478	6 933	1 826	23.26
Gold	4 620	181 873	39 366	14 072	3 046	12.92
Silver–lead–zinc	1 801	68 971	38 296	12 084	6 710	5.71
Miscellaneous metals[1]	546	19 674	36 033	8 360	15 311	2.35
Nickel–copper–zinc[2]	11 585	416 818	35 979	126 658	10 933	3.29
Iron ore	1 308	51 760	39 572	88 231	67 455	0.59
Total	23 656	900 344	38 060	256 338	10 836	3.51

[1] Includes molybdenum mines. [2] Includes copper–zinc and nickel–copper mines.

TABLE 49. CANADA, PERSON–HOURS PAID FOR PRODUCTION AND RELATED WORKERS, AND TONNES OF ORE MINED AND ROCK QUARRIED IN METAL MINES AND OTHER MINERAL OPERATIONS,1980-86

	Unit	1980	1981	1982	1983	1984	1985	1986
Metal mines[1]								
Ore mined	million t	290.1	301.5	238.4	219.0	246.4	245.0	256.3
Person–hours paid[2]	million	97.5	100.6	80.4	71.8	78.2	77.1	73.6
Person–hours paid per tonne mined	number	0.34	0.33	0.34	0.33	0.32	0.31	0.29
Tonnes mined per person–hour paid	t	2.98	3.00	2.97	3.05	3.15	3.18	3.48
Other mineral operations[3]								
Ore mined and rock quarried	million t	106.6	110.5	93.2	101.6	132.3	138.2	127.4
Person–hours paid[2]	million	41.4	38.6	34.8	32.2	34.0	31.3	28.9
Person–hours paid per tonne mined	number	0.39	0.35	0.37	0.32[r]	0.26	0.23	0.23
Tonnes mined per person–hour paid	t	2.57[r]	2.86	2.68	3.16[r]	3.89	4.42[r]	4.41

[1] Excludes placer mining. [2] Person–hours paid for production and related workers only. [3] Includes asbestos, potash, gypsum and coal.

[r] Revised.

TABLE 50. CANADA, AVERAGE WEEKLY WAGES AND HOURS WORKED (INCLUDING OVERTIME) FOR HOURLY–RATED EMPLOYEES IN MINING, MANUFACTURING AND CONSTRUCTION INDUSTRIES, 1981-87

	1981	1982	1983[1]	1984	1985	1986	1987
Mining							
Average hours per week	40.4	39.6	38.8	39.3	39.6	39.7	40.0
Average weekly wage ($)	494.62	551.68	552.79	664.56[r]	697.90[r]	711.05	726.40
Metals							
Average hours per week	40.2	39.0	38.3	38.8	39.1	39.6	39.6
Average weekly wage ($)	485.03	535.92	565.64[r]	610.77[r]	639.89[r]	657.62	678.84
Mineral fuels							
Average hours per week	41.3	42.1	39.7	40.6	40.8[r]	40.9	41.6
Average weekly wage ($)	553.71	631.91	627.26[r]	672.95[r]	716.79[r]	711.40	729.26
Nonmetals							
Average hours per week	38.7	37.2	37.7[r]	38.7	39.2	39.6	39.7
Average weekly wage ($)	445.02	479.44	503.58[r]	536.20[r]	554.88[r]	581.84	595.98
Manufacturing							
Average hours per week	38.5	37.7	38.4	38.5	38.8	38.8	38.8
Average weekly wage ($)	352.08	384.79	504.76	465.66[r]	488.17[r]	504.04[r]	519.54
Construction							
Average hours per week	38.9	38.1	36.9	37.4[r]	37.8	37.9[r]	38.4
Average weekly wage ($)	531.54	564.33	512.26	491.24[r]	505.07[r]	510.40[r]	539.37

[1] Ten–month average: new time series.
[r] Revised.

TABLE 51. CANADA, AVERAGE WEEKLY WAGES (INCLUDING OVERTIME) OF HOURLY-RATED EMPLOYEES IN THE MINING INDUSTRY, IN CURRENT AND 1981 DOLLARS, 1981-87

	1981	1982	1983	1984[1]	1985	1986	1987
Current dollars							
All mining	494.62	551.68	552.79	664.56^{r}	697.90^{r}	711.05	726.40
Metals	485.03	535.92	565.64^{r}	610.77^{r}	639.89^{r}	657.62	678.84
Mineral fuels	553.71	631.91	627.26^{r}	672.95^{r}	716.79^{r}	711.40	729.26
Coal	485.03	567.44^{r}	564.18	653.42^{r}	697.30^{r}	718.82^{r}	729.54
Industrial minerals	445.02	479.44	503.58^{r}	536.20^{r}	554.88^{r}	581.84	595.98
1981 dollars (CPI)							
All mining	494.62	497.90	471.66	543.39	548.66^{r}	537.05^{r}	525.62
Metals	485.03	483.68	482.59	499.40^{r}	503.06^{r}	496.69	491.20
Mineral fuels	553.11	570.32	534.23	550.25^{r}	563.51^{r}	537.31	527.68
Coal	485.03	507.33	481.38	534.28^{r}	548.19^{r}	542.92	527.89
Industrial minerals	445.02	432.71	430.68	438.43^{r}	436.23^{r}	439.46	431.24

[1] Ten-month average: new time series.

CPI Consumer Price Index – all items. ^{r} Revised.

TABLE 52. CANADA, INDUSTRIAL FATALITIES PER THOUSAND WORKERS[1] BY INDUSTRY GROUPS, 1985-87

	Fatalities			Number of Workers			Rate per 1000 Workers		
	1985	1986	1987[p]	1985	1986	1987[p]	1985	1986	1987[p]
		(number)			(000)				
Agriculture	20	9	12	168.0	172.0	179.0	0.12	0.05	0.07
Forestry	66	55	61	61.0[r]	61.0	62.0	1.08[r]	0.90	0.98
Fishing[2]	26	14	24	12.0	14.0	15.0	2.17	1.00	1.60
Mining[3]	131	108	108	189.0[r]	183.0	181.0	0.69[r]	0.59	0.60
Manufacturing[4]	140[r]	111	108	1 951.0[r]	1 985.0	2 017.0	0.07	0.06	0.05
Construction	135[r]	141	118	488.0[r]	522.0	565.0	0.28[r]	0.27	0.21
Transportation[5]	132	122	107	834.0[r]	842.0	848.0	0.16	0.14	0.13
Trade	79[r]	59	40	1 797.0[r]	1 881.0	1 928.0	0.04[r]	0.03	0.02
Finance[6]	5	6	4	599.0[r]	628.0	661.0	0.01	0.01	0.01
Service[7]	56[r]	39	38	3 224.0[r]	3 383.0	3 501.0	0.02	0.01	0.01
Public Administration[8]	56	55	36	802.0[r]	800.0	814.0	0.07[r]	0.07	0.04
Unknown	18	3	9	..	..		..	..	..
Total	864[r]	722	665	10 125.0[r]	10 471.0	10 771.0	0.09	0.07	0.06

[1] Includes fatalities resulting from occupational chest illnesses such as silicosis, lung cancer, etc. Excludes the province of Quebec for which data is unavailable. [2] Includes trapping and hunting. [3] Includes quarrying and oil wells. [4] Includes deaths of workers who were on pension for an earlier disabling injury. [5] Includes storage, communication, electric power and water utilities and highway maintenance. [6] Includes insurance and real estate. [7] Includes community, business and personal services. [8] Includes defence.

.. Not available; [p] Preliminary; [r] Revised.

TABLE 53. CANADA, RATE OF INDUSTRIAL FATALITIES PER THOUSAND WORKERS BY INDUSTRY GROUPS,[1] 1981-87

	1981	1982	1983	1984	1985	1986	1987[p][2]
Agriculture	0.14	0.13	0.13	0.13	0.12	0.05	0.07
Forestry	0.95	1.22	0.97[r]	0.88[r]	1.08[r]	0.90	0.98
Fishing[3]	1.47	1.58	1.07[r]	1.93	2.17	1.00	1.60
Mining[4]	0.76	0.96	0.63[r]	0.57[r]	0.69[r]	0.59	0.60
Manufacturing[5]	0.09	0.11	0.08	0.07[r]	0.07	0.06	0.05
Construction	0.39	0.35	0.25[r]	0.31[r]	0.28[r]	0.27	0.21
Transportation[6]	0.25[r]	0.22	0.17	0.15	0.16	0.14	0.13
Trade	0.04	0.04	0.03[r]	0.03	0.04[r]	0.03	0.02
Finance[7]	0.02	0.01	0.01	0.01[r]	0.01	0.01	0.01
Service[8]	0.03	0.03	0.03	0.02	0.02	0.01	0.01
Public Administration[9]	0.11	0.08	0.07[r]	0.08[r]	0.07[r]	0.07	0.04
Total	0.11	0.11	0.08[r]	0.08[r]	0.09	0.07	0.06

[1] Includes fatalities resulting from occupational chest illnesses such as silicosis, lung cancer, etc. Excludes the province of Quebec for which data is unavailable. [2] Prior to 1983, the rates may be understated because only 80 percent of workers in the Statistics Canada employment estimates are covered by workers' compensation, beginning 1983, the rates include 100 percent of workers. [3] Includes trapping and hunting. [4] Includes quarrying and oil wells. [5] Includes deaths of workers who were on pension for an earlier disabling injury. [6] Includes storage, communication, electric power and water utilities and highway maintenance. [7] Includes insurance and real estate. [8] Includes community, business and personal services. [9] Includes defence.

[p] Preliminary; [r] Revised.

TABLE 54. CANADA, INDUSTRIAL FATALITIES BY OCCUPATIONAL INJURIES AND ILLNESSES,[1] 1985-87

	Occupational Injuries			Occupational Illnesses[2]			Total		
	1985	1986	1987[p]	1985	1986	1987[p]	1985	1986	1987[p]
Agriculture	20[r]	9	12	0	0	0	20[r]	9	12
Forestry	65[r]	55	61	1	0	0	66[r]	55	61
Fishing[3]	26[r]	14	24	0	0	0	26[r]	14	24
Mining[4]	74[r]	57	58	57[r]	51	50	131[r]	108	108
Manufacturing	105[r]	87	69	35[r]	24	39	140[r]	111	108
Construction	109[r]	113	100	26[r]	28	18	135[r]	141	118
Transportation[5]	128[r]	118	104	4	4	3	132[r]	122	107
Trade	73[r]	56	38	6[r]	3	2	79[r]	59	40
Finance[6]	5[r]	6	4	0	0	0	5[r]	6	4
Service[7]	53[r]	37	38	3[r]	2	0	56[r]	39	38
Public Administration[8]	52[r]	50	29	4	5	7	56[r]	55	36
Unknown	2	0	8	1	0	1	3	0	9
Total	712	602	545	137	117	120	849[r]	719	665

[1] Includes fatalities resulting from occupational chest illness such as silicosis, lung cancer, etc. Excludes the province of Quebec for which data is unavailable. [2] Includes trapping and hunting. [3] Includes quarrying and oil wells. [4] Includes deaths of workers who were on pension for an earlier disabling injury. [5] Includes storage, communication, electric power and water utilities and highway maintenance. [6] Includes insurance and real estate. [7] Includes community, business and personal services. [8] Includes defence.

[p] Preliminary; [r] Revised.

TABLE 55. CANADA, NUMBER OF STRIKES AND LOCKOUTS BY INDUSTRIES, 1985-87

	1985			1986			1987[p]		
	Strikes and Lockouts	Workers Involved	Duration in Person-days	Strikes and Lockouts	Workers Involved	Duration in Person-days	Strikes and Lockouts	Workers Involved	Duration in Person-days
Agriculture	1	16	290	0	0	0	1	18	3 800
Forestry	8[r]	1 409[r]	8 120[r]	9	27 813	2 024 930	5	882	2 500
Fishing and trapping	0	0	0	0	0	0	0	0	0
Mines	12	6 309[r]	90 180[r]	14	8 796	351 870	14	8 902	228 440
Manufacturing	356[r]	66 075[r]	1 578 010[r]	317	54 977	1 383 600	303	82 476	1 758 555
Construction	14	992	11 210	48	151 941	1 963 500	21	8 363	53 620
Transportation and utilities	96[r]	38 763[r]	478 900[r]	59	23 859	305 450	64	125 408	700 890
Trade	129[r]	23 196[r]	467 880[r]	109	8 443	234 940	95	8 427	326 250
Finance, insurance and real estate	18	1 137[r]	106 920[r]	13	885	32 570	13	622	29 930
Service	160[r]	15 831[r]	383 900[r]	125	133 695	302 705	114	58 874	555 854
Public administration	31	5 999[r]	55 300[r]	41	73 206	506 860	28	288 707	326 920
Various industries	0	0	0	0	0	0	0	0	0
All industries	825[r]	159 727[r]	3 180 710[r]	735	483 615	7 106 425	658	582 679	3 986 759

[p] Preliminary; [r] Revised.

TABLE 56. CANADA, NUMBER OF STRIKES AND LOCKOUTS BY MINING AND MINERAL MANUFACTURING INDUSTRIES, 1985-87

	1985			1986			1987[p]		
	Strikes and Lockouts	Workers Involved	Duration in Person-days	Strikes and Lockouts	Workers Involved	Duration in Person-days	Strikes and Lockouts	Workers Involved	Duration in Person-days
Mines	12	6 350	91 590	14	8 796	351 870	14	8 902	228 440
Metals	5	4 018	40 760	7	4 700	52 920	10	7551	221 170
Mineral fuels	2	1 400	13 030	4	2 977	231 870	2	1 060	1 000
Nonmetals	3	876	37 260	3	1 119	67 080	1	272	6 210
Quarries	2	56	540	0	0	0	1	19	60
Mineral manufacturing	38	4 050	130 730	41	7136	228 070	41	12 203	451 590
Primary metals	16	2 789	63 400	14	4 422	138 750	21	9 107	369 800
Nonmetallic mineral products	22	1 261	67 330	26	2 598	89 070	20	3 096	81 790
Petroleum and coal products	0	0	0	1	116	250	0	0	0

TABLE 57. CANADA, SOURCE OF ORES HOISTED OR REMOVED FROM SELECTED TYPES OF MINES, 1984-86

Mines	1984r			1985r			1986		
	Underground	Open-pit	Total	Underground	Open-pit	Total	Underground	Open-pit	Total
	(kilotonnes)								
Nickel-copper-zinc	29 916	94 766	124 682	30 184	86 985	117 169	34 769	91 890	126 659
Iron ore	1 796	87 414	89 210	1 953	92 634	94 587	1 660	86 571	88 231
Coal	4 777	66 430	71 207	3 823	72 844	76 667	3 562	69 174	72 736
Potash	36 542	-	36 542	34 843	-	34 843	33 563	-	33 563
Gold	8 293	2 932	11 225	8 424	3 573	11 997	10 208	3 864	14 072
Silver-lead-zinc	7 767	2 317	10 084	7 183	2 787	9 970	7 118	4 965	12 083
Asbestos	1 691	14 035	15 726	1 488	15 630	17 118	1 212	10 596	11 808
Gypsum	1 199	7 670	8 869	1 100	8 508	9 608	1 324	7 851	9 175
Rock salt	6 706	-	6 706	7 101	-	7 101	8 460	-	8 460
Miscellaneous metals	1 582	2 045	3 627	1 288	2 779	4 067	1 127	7 234	8 361
Uranium	7 002	606	7 608	6 627	555	7 182	6 313	620	6 933
Miscellaneous nonmetals	49	3 776	3 825	130	2 906	3 036	409	2 988	3 397
Total	107 320	281 991	389 311	104 144	289 201	393 345	109 725	285 753	395 478
Percentage	27.6	72.4	100.0	26.5	73.5	100.0	27.7	72.3	100.0

r Revised; – Nil.
Note: Totals may not add due to rounding.

TABLE 58. CANADA, SOURCE OF MATERIAL HOISTED OR REMOVED FROM SELECTED TYPES OF MINES, 1986

	Underground		Open–pit			
	Ore	Waste	Ore	Waste	Overburden	Tailings
			(kilotonnes)			
Nickel–copper–zinc	34 769	12 883	91 890	92 349	25 036	119 197
Iron ore	1 660	17	86 571	23 705	6 476	53 107
Coal	3 562	. .	69 174	. .	. .	–
Potash	33 563	22	–	–	–	23 376
Gold	10 208	2 068	3 864	7 061	1 897	12 917
Silver–lead–zinc	7 118	643	4 965	11 852	2 439	10 504
Asbestos	1 212	–	10 596	23 774	468	7 935
Gypsum	1 324	59	7 851	2 431	6 013	73
Rock salt	8 460	605	–	–	–	855
Miscellaneous metals	1 127	63	7 234	3 368	–	5 267
Uranium	6 313	348	620	5 845	1 121	7 058
Miscellaneous nonmetals	409	2	2 988	700	116	427
Total	109 725	16 710	285 753	171 085	43 566	240 716

– Nil; . . Not available.
Note: Totals may not add due to rounding.

TABLE 59. CANADA, ORE MINED AND ROCK QUARRIED IN THE MINING INDUSTRY, 1980–86

	1980	1981	1982	1983	1984	1985	1986[r]
				(kilotonnes)			
Metals							
Nickel–copper–zinc	121 399	137 709	117 833	116 532	124 682	117 169	126 659
Iron	123 107	118 579	81 963	74 597	89 210	94 587	88 231
Gold	6 346	6 810	8 368	9 553	11 225	11 997	14 072
Silver–lead–zinc	16 219	15 964	14 113	9 157	10 084	9 970	12 083
Miscellaneous metals	15 871	15 014	8 477	2 133	3 627	4 067	8 361
Uranium	7 152	7 454	7 608	7 073	7 608	7 182	6 933
Total	290 094	301 530	238 362	219 045	246 436	244 972	256 339
Nonmetals							
Potash	26 988	30 344	16 946	24 222	36 542	34 843	33 563
Asbestos	28 103	25 664	17 493	15 035	15 726	17 118	11 808
Gypsum	7 611	6 220	5 830	7 540	8 869	9 608	9 175
Rock salt	5 321	4 927	5 723	5 996	6 706	7 101	8 460
Miscellaneous nonmetals	3 226	2 788	1 995	2 969	3 825	3 036	3 397
Total	71 249	69 943	47 987	55 762	71 668	71 706	66 403
Structural materials							
Stone, all kinds quarried[1]	103 366	86 860	59 181	67 651	81 754	86 632	112 693
Stone used to make cement	14 138	14 047	10 593	10 154	10 101	8 467	11 535
Stone used to make lime	4 751	1 626	3 411	3 446	4 260	5 137	3 556
Total	122 255	102 533	73 185	81 251	96 115	100 236	127 784
Fuels							
Coal	43 930	48 237	52 979	54 817	71 207	76 667	72 736
Total ore mined and rock quarried	527 528	522 243	412 513	410 875	485 426	493 581	523 262

[1] Excludes stone used to manufacture cement and lime in Canada.
[r] Revised.
Note: Totals may not add due to rounding.

TABLE 60. CANADA, EXPLORATION AND CAPITAL EXPENDITURES IN THE MINING INDUSTRY[1] BY PROVINCES AND TERRITORIES, 1986-88

		Capital						Repair			Total Capital and Repair	Outside or General Exploration	Total, all Expenditures
		Construction				Machinery and Equipment	Total Capital	Construction	Machinery and Equipment	Total Repair			
		On-property Exploration	On-property Development	Structures	Total								
							($ million)						
Newfoundland	1986	(2)	34.3	(2)	35.4	31.2	66.6	(2)	(2)	114.7	181.2	11.4	192.6
	1987[p]	(2)	39.7	(2)	115.4	14.3	129.7	7.4	100.3	107.7	237.4	7.3	244.7
	1988[i]	(2)	(2)	67.1[r]	107.7[r]	19.5[r]	127.2[r]	7.6	102.1	109.7	236.9[r]	6.3[r]	243.2[r]
Prince Edward Island	1986	–	–	–	–	–	–	–	–	–	–	–	–
	1987[p]	–	–	–	–	–	–	–	–	–	–	–	–
	1988[i]	–	–	–	–	–	–	–	–	–	–	–	–
Nova Scotia	1986	(2)	(2)	57.1	169.7	53.1	222.8	1.5	23.1	24.6	247.4	20.5	267.9
	1987[p]	(2)	73.5	(2)	91.2	49.8	141.0	4.4	36.3	40.7	181.7	15.2	196.9
	1988[i]	(2)	13.4[r]	(2)	20.2[r]	61.7[r]	81.9[r]	3.9	36.5	40.4	122.3[r]	20.1[r]	142.4[r]
New Brunswick	1986	1.5	39.2	20.4	61.1	24.5	85.6	9.4	59.8	69.2	154.8	9.3	164.1
	1987[p]	(2)	(2)	6.4	30.0	39.5	69.5	7.6	67.9	75.5	145.0	9.0	154.0
	1988[i]	(2)	(2)	(2)	28.2[r]	31.2[r]	59.4[r]	7.9	74.2	82.1	141.5[r]	17.1[r]	158.6[r]
Quebec	1986	27.9	172.0	61.6	261.5	60.8	322.3	29.1	193.1	222.2	544.5	236.8	781.3
	1987[p]	44.8	199.3	66.2	310.3	82.9	393.2	30.1	190.4	220.5	613.7	432.7	1 046.4
	1988[i]	42.3[r]	216.1[r]	82.8[r]	341.2[r]	107.3[r]	448.5[r]	29.9	192.5	222.4	670.9[r]	452.8[r]	1 123.7[r]
Ontario	1986	33.3	309.3	91.3	433.9	154.0	587.9	40.5	324.5	365.0	952.9	127.1	1 080.0
	1987[p]	32.9	350.6	69.5	453.0	200.2	653.2	38.9	357.4	396.3	1 049.5	171.4	1 220.9
	1988[i]	43.9[r]	426.9[r]	137.1[r]	607.9[r]	334.1[r]	942.0[r]	46.1	368.7	414.8	1 356.8[r]	186.1[r]	1 542.9[r]
Manitoba	1986	7.6	41.2	11.5	60.3	40.2	100.5	(2)	(2)	40.3	140.8	21.9	162.7
	1987[p]	10.7	36.2	21.1	68.0	25.1	93.1	(2)	(2)	39.0	132.1	17.3	149.4
	1988[i]	11.5[r]	45.7[r]	3.4[r]	60.6[r]	31.2[r]	91.8[r]	(2)	(2)	43.0	134.8[r]	18.0[r]	152.8[r]
Saskatchewan	1986	5.8	54.9	47.9	108.6	87.2	195.8	6.5	135.9	142.4	338.2	32.6	370.8
	1987[p]	4.3	111.0	11.1	126.4	43.5	169.9	7.3	128.7	136.0	305.9	36.7	342.6
	1988[i]	(2)	100.1[r]	(2)	129.1[r]	75.5[r]	204.6[r]	6.9	130.7	137.6	342.2[r]	44.2[r]	386.4[r]
Alberta	1986	(2)	(2)	5.4	22.2	26.0	48.2	2.8	73.0	75.8	124.0	11.5	135.5
	1987[p]	(2)	8.5	(2)	13.8	26.1	39.9	0.4	73.7	74.1	114.0	4.0	118.0
	1988[i]	(2)	15.4[r]	(2)	25.9[r]	46.3[r]	72.2[r]	0.4	81.8	82.2	154.4[r]	5.1[r]	159.5[r]
British Columbia	1986	9.4	228.9	32.9	271.2	92.5	363.7	22.3	367.9	390.2	753.9	74.9	828.8
	1987[p]	15.5	247.5	79.8	342.8	95.1	437.9	21.2	379.6	400.8	838.7	105.3	944.0
	1988[i]	17.6[r]	305.6[r]	131.6[r]	454.8[r]	117.1[r]	571.9[r]	22.3	390.3	412.6	984.5[r]	131.1[r]	1 115.6[r]
Yukon	1986	1.8	0.9	0.1	2.8	1.1	3.9	(2)	(2)	4.2	8.1	16.7	24.8
	1987[p]	0.6	(2)	(2)	13.4	5.6	19.0	(2)	(2)	24.2	43.2	16.8	60.0
	1988[i]	4.0[r]	10.9[r]	–	14.9[r]	8.8[r]	23.7[r]	(2)	(2)	21.5	45.2[r]	8.5[r]	53.7[r]
Northwest Territories	1986	19.9	16.9	18.7	55.5	5.4	60.9	4.5	54.4	58.9	119.8	26.5	146.3
	1987[p]	2.1	20.6	9.0	31.7	18.2	49.9	2.8	45.2	48.0	97.9	33.9	131.8
	1988[i]	(2)	24.3[r]	(2)	64.7[r]	31.0[r]	95.7[r]	14.9	47.1	62.0	157.7[r]	24.3[r]	182.0[r]
Canada	1986	108.6	1 026.1	347.4	1 482.1	576.0	2 058.1	130.8	1 376.7	1 507.5	3 565.6	589.3	4 154.9
	1987[p]	121.5	1 115.7	359.0	1 596.1	600.0	2 196.2	120.4	1 442.4	1 562.8	3 759.1	849.6	4 608.7
	1988[i]	143.9[r]	1 219.7[r]	491.7[r]	1 855.3[r]	863.9[r]	2 719.2[r]	141.0	1 488.1	1 629.1	4 348.3[r]	913.7[r]	5 262.0[r]

---

[1] Excludes expenditures in the petroleum and natural gas industries (2) Confidential, included in total

[p] Preliminary; [r] Revised; [i] Intentions; – Nil

Note: Totals may not add due to rounding

TABLE 61. CANADA, EXPLORATION AND CAPITAL EXPENDITURES[1] IN THE MINING INDUSTRY BY TYPE OF MINING, 1986-88

		Capital						Repair					
		Construction											
		On-property Exploration	On-property Development	Structures	Total	Machinery and Equipment	Total Capital	Construction	Machinery and Equipment	Total Repair	Total Capital and Repair	Outside or General Exploration	Total, all Expenditures
							($ million)						
Metal Mines													
Copper-gold-silver	1986	28.2	91.9	52.4	172.5	50.9	223.4	22.0	203.1	225.1	448.5	16.0	464.5
	1987p	18.9	90.9	72.8	182.6	47.1	229.7	19.0	240.5	259.5	489.2	20.8	510.0
	1988i	15.6r	131.2r	86.9r	233.7r	51.4r	285.1r	18.0	239.3	257.3	542.4r	16.4r	558.8r
Gold	1986	51.3	223.1	121.5	395.9	120.1	516.0	22.5	103.5	126.0	642.0	69.2	711.2
	1987p	65.5	337.2	179.2	581.9	155.2	737.1	17.0	119.6	136.6	873.7	95.2	968.9
	1988i	76.8r	408.3r	266.1r	751.2r	275.6r	1 026.8r	34.4	138.2	172.6	1 199.4r	113.3r	1 312.7r
Iron	1986	(4)	69.4	(4)	76.6	41.7	118.3	12.7	189.5	202.2	320.5	4.8	325.3
	1987p	(4)	93.2	(4)	102.0	14.6	116.6	10.4	168.4	178.8	295.4	(4)	(4)
	1988i	(4)	94.5r	(4)	99.2r	27.7r	126.9r	10.5	170.1	180.6	307.5r	(4)	(4)
Silver-lead-zinc	1986	9.0	33.6	12.0	54.6	8.1	62.7	11.9	72.8	84.7	147.4	15.5	162.9
	1987p	5.7	50.7	13.9	70.3	48.0	118.3	9.1	99.3	108.4	226.7	16.9	243.6
	1988i	8.8r	56.3r	14.8r	79.9r	43.1r	123.0r	9.1	109.9	119.0	242.0r	19.8r	261.8r
Uranium	1986	5.2	107.2	1.9	114.3	29.2	143.5	5.9	118.1	124.0	267.5	16.9	284.4
	1987p	(4)	74.4	(4)	82.8	23.5	106.3	8.6	123.1	131.7	238.0	17.8	255.8
	1988i	(4)	101.4r	(4)	129.7r	43.6r	173.3r	9.1	121.5	130.6	303.9r	(4)	(4)
Other metal mining[2]	1986	(4)	109.8	(4)	156.4	65.5	221.9	24.2	115.1	139.3	361.2	3.9	365.1
	1987p	10.0	89.8	12.7	112.5	59.6	172.1	25.9	124.5	150.4	322.5	(4)	(4)
	1988i	17.2r	128.9r	29.7r	175.8r	114.6r	290.4r	27.9	126.4	154.3	444.7r	(4)	(4)
Total metal mining	1986	100.5	635.0	234.8	970.3	315.5	1 285.8	99.2	802.1	901.3	2 187.1	126.3	2 313.4
	1987p	104.0	736.2	292.0	1 132.2	348.0	1 480.2	90.0	875.4	965.4	2 445.6	156.6	2 602.2
	1988i	123.0r	920.3r	425.9r	1 469.2r	556.0r	2 025.2r	109.0	905.4	1 014.4	3 039.6r	183.0r	3 222.6r
Nonmetal Mines													
Asbestos	1986	(4)	36.3	(4)	41.4	2.2	43.6	1.9	37.3	39.2	82.8	–	82.8
	1987p	(4)	34.5	(4)	40.0	11.2	51.2	(4)	(4)	47.0	98.2	–	98.2
	1988i	(4)	11.9r	(4)	12.4r	2.6r	15.0r	(4)	(4)	54.9	69.9r	–	69.9r
Coal	1986	2.5	307.8	29.6	339.9	89.2	429.1	15.9	310.9	326.8	755.9	20.5	776.4
	1987p	2.1	236.6	19.9	258.6	96.5	355.1	13.2	300.8	314.0	669.1	8.4	677.5
	1988i	(4)	195.0r	(4)	210.8r	155.9r	366.7r	13.7	302.0	315.7	682.4r	5.0r	687.4r
Other nonmetal mining[3]	1986	(4)	46.6	(4)	121.1	165.2	286.3	13.4	217.2	230.6	516.9	1.6	518.5
	1987p	(4)	101.5	(4)	121.4	133.6	255.0	(4)	(4)	232.2	487.2	3.0	490.2
	1988i	2.5r	86.9r	39.1r	128.5r	145.1r	273.6r	(4)	(4)	238.8	512.4r	2.2r	514.6r
Total nonmetal mining	1986	8.1	390.7	103.6	502.4	256.6	759.0	31.2	565.4	596.6	1 355.6	22.1	1 377.7
	1987p	6.4	372.6	41.0	420.0	241.3	661.2	27.5	565.7	593.2	1 254.4	11.4	1 265.9
	1988i	4.5r	293.8r	53.4r	351.7r	303.6r	655.3r	28.4	581.0	609.4	1 264.7r	7.2r	1 271.9r
Metal and Nonmetal Exploration Companies	1986	–	0.4	8.9	9.4	3.9	13.2	0.4	9.2	9.6	22.8	440.9	463.7
	1987p	11.1	6.9	26.0	44.0	11.0	55.0	3.2	1.4	4.6	59.6	681.6	741.2
	1988i	16.5r	5.3r	12.4r	34.2r	3.9r	38.1r	3.6	1.7	5.3	43.4r	723.6r	767.0r
Total mining	1986	108.6	1 026.1	347.4	1 482.1	576.0	2 058.1	130.8	1 376.7	1 507.5	3 565.6	589.3	4 154.9
	1987p	121.5	1 115.7	359.0	1 596.2	600.0	2 196.2	120.4	1 442.4	1 562.8	3 759.0	849.6	4 608.6
	1988i	143.9r	1 219.7r	491.7r	1 855.3r	863.9r	2 719.2r	141.0	1 488.1	1 629.1	4 348.3r	913.7r	5 262.0r

---

[1] Excludes expenditures in the petroleum and natural gas industries. [2] Includes nickel-copper mines, silver-cobalt mines and other metal mines. [3] Includes gypsum mines, salt mines, potash mines, quarries, sand and gravel pits and other nonmetal mines. (4) Confidential, included in total.
p Preliminary; r Revised; i Intentions; – Nil.
Note: Totals may not add due to rounding.

TABLE 62. CANADA, DIAMOND DRILLING IN THE MINING INDUSTRY BY MINING COMPANIES WITH OWN EQUIPMENT AND BY DRILLING CONTRACTORS, 1984-86

		1984			1985			1986		
		Exploration	Other	Total	Exploration	Other	Total	Exploration	Other	Total
						(metres)				
Metal mines										
Gold	Own equipment	38 223	1 062	39 285	51 906	22 642^{r}	74 548^{r}	50 003	161 919	211 922
	Contractors	362 358	4 417	366 775	349 405	5 612^{r}	355 017^{r}	553 141	9 833	562 974
	Total	400 581	5 479	406 060	401 311	28 254	429 565	603 144	171 752	774 896
Nickel-copper-zinc	Own equipment	202 223	308 471	510 694	228 851	-	228 851	185 156	11 568	196 724
	Contractors	319 842	-	319 842	246 731	-	246 731	237 601	-	237 601
	Total	522 065	308 471	830 536	475 582	-	475 582	422 757	11 568	434 325
Iron mines	Own equipment	-	178 684	178 684	-	203 876	203 876	15 000	199 336	214 336
	Contractors	660	-	660	5 295	-	5 295	3 900	-	3 900
	Total	660	178 684	179 344	5 295	203 876	209 171	18 900	199 336	218 236
Silver-lead-zinc	Own equipment	67 559	4 772	72 331^{r}	60 074	3 983	64 057	59 334	6 000	65 334
	Contractors	200 957	-	200 957	88 345	290	88 635	98 422	-	98 422
	Total	268 516	4 772	273 288^{r}	148 419	4 273	152 692	157 756	6 000	163 756
Uranium	Own equipment	47 675	-	47 675	41 659	-	41 659	37 661	-	37 661
	Contractors	23 716	-	23 716	12 827	-	12 827	233	-	233
	Total	71 391	-	71 391	54 486	-	54 486	37 894	-	37 894
Miscellaneous metal mining	Own equipment	2 000	-	2 000	-	-	-	-	-	-
	Contractors	28 926	-	28 926	22 707	400	23 107	22 512	-	22 512
	Total	30 926	-	30 926	22 707	400	23 107	22 512	-	22 512
Total metal mining	Own equipment	357 680	492 989^{r}	850 669^{r}	382 490	230 501	612 991	347 154	378 823	725 977
	Contractors	936 459	4 417	940 876	725 310	6 302	731 612	915 809	9 833	925 642
	Total	1 294 139	497 406^{r}	1 791 545^{r}	1 107 800	236 803	1 344 603	1 262 963	388 656	1 651 619
Nonmetal mines										
Gypsum	Own equipment	-	-	-	-	-	-	-	-	-
	Contractors	3 319	-	3 319	521	2 183	2 704	4 632	9 144	13 776
	Total	3 319	-	3 319	521	2 183	2 704	4 632	9 144	13 776
Other nonmetal mines	Own equipment	360	-	360	8 334^{r}	-	8 334r	1 710	-	1 710
	Contractors	4 191	-	4 191	3 064	-	3 064	1 430	-	1 430
	Total	4 551	-	4 551	11 398^{r}	-	11 398r	3 140	-	3 140
Asbestos	Own equipment	-	-	-	-	-	-	-	-	-
	Contractors	3 293	-	3 293	5 160	-	5 160	2 851	-	2 851
	Total	3 293	-	3 293	5 160	-	5 160	2 851	-	2 851
Potash	Own equipment	-	-	-	3 139	-	3 139	-	-	-
	Contractors	-	-	-	-	-	-	-	-	-
	Total	-	-	-	3 139	-	3 139	-	-	-
Total nonmetal mining	Own equipment	360	-	360	11 473	-	11 473	1 710	-	1 710
	Contractors	10 803	-	10 803	8 745	2 183	10 928	8 913	9 144	18 057
	Total	11 163	-	11 163	20 218	2 183	22 401	10 623	9 144	19 767
Total mining industry	Own equipment	358 040	492 989^{r}	851 029^{r}	393 963	230 501	624 464	348 864	378 823	727 687
	Contractors	947 262	4 417	951 679	734 055	8 485	742 540	924 722	18 977	943 699
	Total	1 305 302	497 406^{r}	1 802 708^{r}	1 128 018	238 986	1 367 004	1 273 586	397 800	1 671 386

^{r} Revised – Nil
Note Totals may not add due to rounding

TABLE 63. CANADA, ORE MINED AND ROCK QUARRIED IN THE MINING INDUSTRY, 1957–86

	Metals	Industrial[1]	Coal	Total
		(million tonnes)		
1957	76.4	74.5		150.9
1958	71.4	71.2		142.6
1959	89.9	82.2		172.1
1960	92.1	88.7		180.8
1961	90.1	96.7		186.8
1962	103.6	103.8		207.4
1963	112.7	120.4		233.1
1964	128.0	134.1		262.1
1965	151.0	146.5		297.5
1966	147.6	171.8		319.4
1967	169.1	177.5		346.6
1968	186.9	172.7		359.6
1969	172.0	178.8		350.8
1970	213.0	179.1		392.1
1971	211.5	185.8		397.3
1972	206.0	189.7		395.7
1973	274.9	162.6		437.4
1974	278.7	178.8		457.5
1975	264.2	158.7		422.9
1976	296.5	167.1		463.6
1977	299.5	205.2	33.8	538.5
1978	248.1	205.5	36.3	489.9
1979[r]	274.8	200.1	39.8	514.6
1980[r]	290.1	193.5	43.9	527.5
1981[r]	301.5	172.5	48.2	522.2
1982[r]	238.4	121.2	53.0	412.5
1983[r]	219.0	137.0	54.8	410.9
1984[r]	246.4	167.8	71.2	485.4
1985[r]	245.0	171.9	76.7	493.6
1986[r]	256.3	194.2	72.7	523.3

[1] Includes nonmetallic mineral mining and all stone quarried, including stone used to make cement and lime. From 1979 onwards, coverage includes miscellaneous nonmetal mines previously excluded.

[r] Revised.

Note: Totals may not add due to rounding.

TABLE 64. CANADA, TOTAL DIAMOND DRILLING, METAL DEPOSITS, 1957–86

	Gold Deposits	Copper–zinc and Nickel–copper Deposits	Silver–lead–zinc Deposits	Other Metal Bearing Deposits[1]	Total Metal Deposits
			(metres)		
1957	706 273	1 098 490	323 704	287 364	2 415 831
1958	546 861	923 026	297 792	286 970	2 054 649
1959	558 160	1 110 664	282 088	383 471	2 334 383
1960	628 016	1 267 792	226 027	315 067	2 436 902
1961	595 180[r]	1 128 091	255 101	221 079	2 199 451[r]
1962	902 288	1 025 048	350 180	358 679	2 636 195
1963	529 958	977 257	288 204	148 703	1 944 122
1964	458 933	709 588	401 099	104 738	1 674 358
1965	440 020	779 536	331 294	275 917	1 826 767[r]
1966	442 447	729 148	292 223	164 253	1 628 071
1967	391 347	947 955	230 182	120 350	1 689 834
1968	375 263	935 716	198 038	56 780	1 565 797
1969	274 410	923 452	197 670	109 592	1 505 124
1970	214 717	1 132 915	375 019	99 373	1 822 024
1971	193 291	1 089 103	308 798	83 851	1 675 043
1972	229 771	967 640	240 195	50 225	1 487 831
1973	243 708	713 134	185 946	57 730	1 200 518
1974	250 248	798 564	197 322	83 484	1 329 618
1975	216 158	532 991	184 203	97 971	1 031 323
1976	156 030	507 620	166 366	97 735	927 751
1977	175 643	515 780	213 279	124 329	2 039 031
1978	209 335	346 722[r]	490 489	135 197	1 181 743
1979	198 955	437 562	131 032	150 018	917 567
1980	187 635	566 610	259 877	173 945	1 188 067
1981	306 197	675 712	478 754	170 369	1 631 032
1982	288 421	386 940	424 218	164 742	1 264 321
1983	352 218	512 745	269 659	97 661	1 232 283
1984	406 060	830 536	273 288[r]	281 661	1 791 545[r]
1985	429 565	475 582	152 692	286 764	1 344 603
1986	774 896	434 325	163 756	278 642	1 651 619

[1] Includes iron, titanium, uranium, molybdenum and other metal deposits

[r] Revised

TABLE 65. CANADA, EXPLORATION DIAMOND DRILLING, METAL DEPOSITS, 1957–86

	Mining Companies with Own Personnel and Equipment	Diamond Drill Contractors	Total
		(metres)	
1957	358 300	1 233 323	1 591 623
1958	237 133	1 200 625	1 437 758
1959	239 786	1 367 061	1 606 847
1960	268 381	1 409 416	1 677 797
1961	302 696	1 337 173	1 639 869
1962	167 214	1 748 023	1 915 237
1963	361 180	1 169 292	1 530 472
1964	143 013	1 072 985	1 215 998
1965	209 002	1 176 996	1 385 998
1966	163 379	1 044 860	1 208 239
1967	93 164	1 123 137	1 216 301
1968	159 341	990 690	1 150 031
1969	135 311	1 072 328	1 207 639
1970	62 147	1 228 061	1 290 208
1971	86 838	1 053 330	1 140 168
1972	251 651	839 753	1 091 404
1973	321 333	742 899	1 064 232
1974	357 823	892 557	1 250 380
1975	346 770	618 161	964 931
1976	335 919	532 036	867 955
1977	327 241	638 327	965 568
1978	237 250	534 557	771 807
1979	311 221	571 721	882 942
1980	347 829	747 566	1 095 395
1981	460 687	917 566	1 378 253
1982	289 901	713 413	1 003 314
1983	324 383	707 343	1 031 726
1984	357 680	936 459	1 294 139
1985	382 490	725 310	1 107 800
1986	347 154	915 809	1 262 963

TABLE 66. CANADA, DIAMOND DRILLING, OTHER THAN FOR EXPLORATION, METAL DEPOSITS, 1957-86

	Mining Companies with Own Personnel and Equipment	Diamond Drill Contractors	Total
		(metres)	
1957	524 724	156 060	680 784
1958	444 376	172 516	616 892
1959	488 783	238 753	727 536
1960	450 246	308 860	759 106ʳ
1961	384 432	175 149	559 581
1962	528 700	192 259	720 959
1963	388 228	25 422	413 650
1964	385 765	72 594	458 359
1965	393 947	46 822	440 769
1966	227 968	191 863	419 831
1967	186 463	287 071	473 534
1968	122 851	292 914	415 765
1969	87 552	209 933	297 485
1970	290 363	241 453	531 816
1971	295 966	238 910	534 876
1972	304 523	91 903	396 426
1973	77 162	59 124	136 286
1974	54 353	24 885	79 238
1975	31 917	34 475	66 392
1976	31 413	28 383	59 796
1977	24 303	39 160	63 463
1978	351 344	58 592	409 936
1979	4 090	30 535	34 625
1980	20 545	72 127	92 672
1981	200 898	51 881	252 779
1982	188 674	72 333	261 007
1983	81 138	119 419	200 557
1984	492 989ʳ	4 417	497 406ʳ
1985	230 501	6 302	236 803
1986	378 823	9 833	388 656

ʳ Revised.
Nonproducing companies excluded since 1964

TABLE 67. CANADA, CRUDE MINERALS TRANSPORTED BY CANADIAN RAILWAYS, 1984–86

	1984	1985	1986
		(kilotonnes)	
Metallic minerals			
Iron ores and concentrates	35 269	39 197	36 688
Nickel-copper ores and concentrates	4 228	4 161	4 084
Alumina and bauxite	3 523	3 227	3 503
Copper ores and concentrates	1 495	1 467	1 357
Zinc ores and concentrates	1 693	1 452	993
Lead ores and concentrates	1 507	604	912
Metallic ores and concentrates, n.e.s.	41	73	10
Nickel ores and concentrates	–	–	–
Total metallic minerals	47 756	50 181	47 547
Nonmetallic minerals			
Potash (KC1)	10 937	9 891	10 266
Sulphur, n.e.s.	5 948	6 355	5 831
Gypsum	5 449	5 492	5 512
Limestone, n.e.s.	2 832	2 312	2 997
Phosphate rock	2 102	1 838	1 612
Sand, industrial	927	879	888
Sulphur, liquid	1 989	1 529	839
Salt, rock	819	650	799
Clay	607	632	790
Sodium carbonate	492	485	560
Limestone, industrial	264	418	455
Sodium sulphate	440	386	385
Nepheline syenite	274	241	242
Sand, n.e.s.	319	321	227
Nonmetallic minerals, n.e.s.	168	181	177
Limestone, agricultural	94	85	128
Salt, n.e.s.	102	101	101
Stone, n.e.s.	72	70	57
Asbestos	99	81	31
Abrasives, natural	33	20	17
Barite	23	13	14
Silica	12	11	14
Peat and other mosses	27	22	10
Total nonmetallic minerals	34 029	32 013	31 951
Mineral fuels			
Coal, bituminous	37 577	41 539	40 386
Coal, lignite	1 627	1 336	1 236
Coal, n.e.s.	85	54	63
Natural gas and other crude bituminous substances	28	37	31
Oil, crude	4	5	8
Total mineral fuels	39 321	42 971	41 724
Total crude minerals	121 106	125 165	121 223
Total revenue freight moved by Canadian railways	254 581	250 608	249 786
Percent crude minerals of total revenue freight	47.6	49.9	48.5

n.e.s. Not elsewhere specified; – Nil.

71.70

TABLE 68. CANADA, FABRICATED MINERAL PRODUCTS TRANSPORTED BY CANADIAN RAILWAYS, 1984–86

	1984	1985	1986
		(kilotonnes)	
Metallic minerals products			
Ferrous mineral products			
Iron and steel scrap	2 272	2 533	1 926
Sheets and strips, steel	1 022	1 072	829
Ingots, blooms, billets, slabs of iron and steel	1 064	907	804
Bars and rods, steel	705	715	683
Structural shapes and sheet piling, iron and steel	441	495	523
Plates, steel	430	426	350
Pipes and tubes, iron and steel	285	334	190
Castings and forgings, iron and steel	139	106	94
Rails and railway track material	94	59	62
Pig iron	65	22	59
Ferroalloys	48	43	48
Other primary iron and steel	27	29	33
Wire, iron or steel	12	8[r]	10
Total ferrous mineral products	6 604	6 749[r]	5 611
Nonferrous mineral products			
Aluminum and aluminum alloy fabricated material, n.e.s	781	889	1 041
Zinc and alloys	504	536	483
Aluminum paste, powder, pigs, ingots, shot	160	273	457
Copper and alloys, n.e.s.	467	407	401
Lead and alloys	149	170	143
Nonferrous metal scrap	105	98	86
Other nonferrous base metals and alloys	177	177[r]	74
Slag, dross, etc.	116	99	55
Copper matte and precipitates	526	4	4
Total nonferrous mineral products	2 985	2 653[r]	2 744
Total metallic mineral products	9 589	9 402	8 355
Nonmetallic mineral products			
Fertilizers and fertilizer materials, n.e.s.	2 195	1 815	2 143
Portland cement, standard	1 409	1 687	1 665
Sulphur acid	1 322	1 422	1 490
Gypsum basic products, n.e.s.	198	254	357
Cement and concrete basic products, n.e.s	188	164	258
Nonmetallic mineral basic products, n.e.s	271	224	197
Natural stone basic products, chiefly structural	202	160	172
Lime, hydrated and quick	155	139	104
Dolomite and magnesite, calcined	78	77	76
Glass basic products	57	47	40
Fire brick and similar shapes	46	28	23
Bricks and tiles, clay	8	12	18
Refractories, n.e.s.	10	5	10
Plaster	5	9[r]	5
Asbestos and asbestos-cement basic products	3	3[r]	5
Total nonmetallic mineral products	6 147	6 046	6 563
Mineral fuel products			
Refined and manufactured gases, fuel type	2 711	2 825	2 333
Diesel fuel	1 967	1 690	1 430
Gasoline	1 273	1 077	949
Coke, n.e.s.	663	672	732
Fuel oil, n.e.s.	843	680	725
Other petroleum and coal products	694	701	685
Petroleum coke	516	521	408
Asphalts and road oils	306	374	347
Lubricating oils and greases	372	337	312
Total mineral fuel products	9 345	8 877	7 922
Total fabricated mineral products	25 081	24 325	22 841
Total revenue freight moved by Canadian railways	254 581	250 608	249 786
Fabricated mineral products as a percentage of total revenue freight	9.9	9.7	9.1

n.e.s. Not elsewhere specified, [r] Revised.

TABLE 69. CANADA, CRUDE AND FABRICATED MINERALS TRANSPORTED BY CANADIAN RAILWAYS, 1956–86

	Total Revenue Freight	Total Crude Minerals	Total Fabricated Minerals	Total Crude and Fabricated Minerals	Crude and Fabricated Minerals as Percent of Revenue Freight
	(million tonnes)				
1956	172.0	68.7	21.8	90.5	52.6
1957	157.9	64.2	17.1	81.3	51.5
1958	139.2	52.4	15.2	67.6	48.6
1959	150.6	68.2	15.3	78.1	51.9[r]
1960	142.8	57.1	14.5	71.6	50.1
1961	138.9	54.1	13.6	67.7	48.7
1962	146.0	60.3	13.8	74.1	50.8
1963	154.6	62.9	15.5	78.4	50.6
1964	180.0	74.6	15.9	90.5	50.3
1965	186.2	80.9	17.3	98.2	52.7
1966	194.5	80.6	17.8	98.4	50.6
1967	190.0	81.2	17.7	98.9	52.1
1968	195.4	86.7	18.8	105.5	54.0
1969	189.0	81.9	27.6	109.5	57.9
1970	211.6	97.5	28.4	125.9[r]	59.5[r]
1971	214.5	95.6	27.4	123.0	57.3
1972	215.8	89.4	27.6	117.0	54.2
1973	241.2	113.1	29.1	142.2	59.0
1974	246.3	115.3	30.9	146.2	59.4
1975	226.0	110.6	26.6	137.2	60.7
1976	238.5	116.6	25.5	142.1	59.6
1977	247.2	121.1	25.7	146.8	59.4
1978	238.8	107.7	26.2	133.9	56.1[r]
1979	257.9	127.2	26.6	153.8	59.6
1980	254.4	124.8	24.6	149.4	58.7
1981	246.6	120.7	26.4	147.1	59.7
1982	212.5	95.7	21.0	116.7	54.9
1983	222.8	95.3	22.7[r]	118.0[r]	53.0[r]
1984	254.6	121.1	25.1	146.2	57.4
1985	250.6	125.2	24.3	149.5	59.7
1986	249.8	121.2	22.8	144.1	57.7

[r] Revised.

TABLE 70. CANADA, CRUDE AND FABRICATED MINERALS TRANSPORTED THROUGH THE ST. LAWRENCE SEAWAY[1], 1985-87

	Montreal – Lake Ontario Section			Welland Canal Section		
	1985	1986	1987	1985	1986	1987
			(tonnes)			
Crude minerals						
Iron ore	8 679 210	8 026 080	9 557 376	6 788 799	5 839 484	6 180 641
Coal	607 108	609 619	233 756	5 807 694	5 775 521	5 644 283
Salt	657 494	874 520	928 559	1 521 180	1 882 656	1 766 446
Other crude minerals	976 405	1 008 788	1 176 688	479 778	588 905	731 820
Stone, ground or crushed	258 745	271 945	231 637	815 313	1 005 726	889 303
Aluminum ores and concentrates	200 890	196 830	169 584	198 890	175 508	136 984
Clay and bentonite	162 410	161 366	164 766	162 410	161 366	164 766
Sand and gravel	1	16 009	–	176 291	82 436	89 372
Phosphate rock	23 522	28 730	47 223	–	–	–
Stone, rough	302	203	21	302	182	–
Potash	122 886	192 435	55 098	252 732	262 357	83 312
Total crude minerals	11 688 973	11 386 525	12 564 708	16 203 389	15 774 141	15 686 927
Fabricated mineral products						
Iron and steel, manufactured	2 798 848	2 922 806	2 633 980	2 407 431	2 385 475	2 197 601
Coke	802 266	867 412	654 432	921 887	993 268	822 061
Scrap iron and steel	635 622	740 276	344 352	753 927	782 966	372 318
Fuel oil	558 770	641 156	481 049	628 613	603 625	569 051
Iron and steel, bars, rods, slabs	791 144	615 469	972 396	675 205	455 565	469 961
Cement	175 111	152 616	242 758	309 120	347 060	549 874
Gasoline	111 419	206 107	167 472	141 601	186 564	97 982
Other petroleum products	84 179	110 263	181 447	76 295	114 252	136 429
Pig iron	103 610	96 925	124 355	89 263	71 730	104 815
Tar, pitch and creosote	35 892	39 222	22 946	69 324	54 810	49 030
Lubricating oils and greases	41 964	25 850	59 826	41 962	15 290	27 119
Iron and steel, nails, wire	13 229	10 527	8 027	12 287	9 030	6 951
Total fabricated minerals	6 152 054[r]	6 428 629	5 893 040	6 126 915	6 019 635	5 403 192
Total crude and fabricated minerals	17 841 027	17 815 154	18 457 748	22 330 304	21 793 776	21 090 119
Total, all products	37 321 698	37 581 808	39 968 615	41 851 760	41 612 770	42 724 755
Crude and fabricated minerals as a percent of total	47.8	47.4	46.2	53.4	52.4	49.4

[1] Total cargo transported regardless of travel direction

– Nil. [r] Revised

TABLE 71. CANADA, CRUDE AND FABRICATED MINERALS TRANSPORTED THROUGH THE ST. LAWRENCE SEAWAY[1], 1957–87

	Montreal – Lake Ontario Section				Welland – Canal Section			
	Total All Products	Total Crude Minerals	Total Fabricated Minerals	Crude and Fabricated Minerals as Percent of All Products	Total All Products	Total Crude Minerals	Total Fabricated Minerals	Crude and Fabricated Minerals as Percent of All Products
	(kilotonnes)				(kilotonnes)			
1957	11 059	4 439	1 392	52.7	20 296	11 305	2 421	67.6
1958	10 670	3 064	1 020	38.3	19 300	8 994	2 107	57.5
1959	19 252	7 725	2 197	51.5	24 953	12 117	2 246	57.6
1960	18 460	5 760	2 904	46.9	26 563	12 679	2 606	57.5
1961	21 212	6 706	2 358	42.7	28 490	12 599	2 378	52.7
1962	23 271	7 531	2 522	43.2	32 215	15 625	2 342	55.8
1963	28 198	9 507	2 804	43.7	37 490	18 094	2 524	55.0
1964	35 701	13 127	3 558	46.7	46 644	23 489	3 095	57.0
1965	39 352	13 788	6 024	50.3	48 477	23 555	4 933	58.8
1966	44 538	16 376	6 340	51.0	53 648	25 712	5 329	57.8
1967	39 918	17 800	6 430	60.7	47 945	26 010	5 459	65.6
1968	43 496	19 312	8 425	63.8	52 712	29 075	7 587	69.6
1969	37 256	12 682	8 263	56.2	48 601	25 090	6 715	65.4
1970	46 445	15 554	8 932	52.7	57 121	27 233	7 156	60.2
1971	48 069	14 204	9 263	48.8	57 205	23 903	7 914	55.6
1972	48 607	13 425	9 837	47.9	58 146	24 808	7 701	55.9
1973	52 285	17 111	9 639	51.1	60 958	26 907	7 718	56.8
1974	40 049	16 137	7 018	57.8	47 500	23 952	5 437	61.9
1975	43 554	15 698	6 071	50.0	53 387	26 100	5 129	58.5
1976	49 348	20 884	7 181	56.9	58 368	29 914	6 323	62.1
1977	57 456	23 008	9 918	57.3	65 079	30 459	8 933	60.5
1978	51 658	15 057	8 558	45.7	59 576	22 700	7 759	51.1
1979	50 187	16 408	8 104	48.8	60 023	24 851	7 940	54.6
1980	42 142	12 248	6 009	43.3	54 074	20 487	5 405	57.9
1981	45 876	15 453	5 711	46.1	53 389	22 132	5 529	51.8
1982	38 841	9 146	4 997	36.4	44 474	15 057	4 333	45.9
1983	45 061	12 443	5 422	39.6	50 145	17 412	5 618	45.9
1984	47 505	14 009	6 980	44.2	53 917	20 312	7 052	50.8
1985	37 322	11 689	6 152	47.8	41 852	16 203	6 127	53.4
1986	37 582	11 387	6 429	47.4	41 613	15 774	6 020	52.4
1987	39 969	12 565	5 893	46.2	42 725	15 687	5 403	49.4

[1] Total cargo transported regardless of travel direction

TABLE 72. CANADA, CRUDE MINERALS LOADED AND UNLOADED IN COASTWISE SHIPPING, 1987P

	Loaded				Unloaded			
	Atlantic	Great Lakes	Pacific	Total	Atlantic	Great Lakes	Pacific	Total
	(tonnes)							
Metallic minerals								
Iron ore and concentrates	6 200 950	70 052	998	6 272 000	1 429 432	4 841 570	998	6 272 000
Titanium ore	2 124 142	–	–	2 124 142	2 124 142	–	–	2 124 142
Metallic ores and concentrates, n.e.s.	339	40 503	–	40 842	339	40 503	–	40 842
Zinc ore and concentrates	–	–	15 317	15 317	–	–	15 317	15 317
Total metals	8 325 431	110 555	16 315	8 452 301	3 553 913	4 882 073	16 315	8 452 301
Nonmetallic minerals								
Limestone	381	3 193 433	1 651 209	4 845 023	381	3 193 433	1 651 209	4 845 023
Salt	1 072 952	1 405 856	–	2 478 808	1 778 633	700 176	–	2 478 809
Gypsum	1 034 472	–	7 593	1 042 065	719 145	287 329	35 591	1 042 065
Sand and gravel	229 549	69 279	622 410	921 238	229 549	69 279	622 410	921 238
Stone, crude, n.e.s.	53	198 624	6 540	205 217	53	198 624	6 540	205 217
Potash	73	129 341	–	129 414	41 083	88 331	–	129 414
Quartz-silica	49 629	42 181	553	92 363	26	91 784	553	92 363
Sulphur crude and refined	5 566	–	3 988	9 554	5 566	–	3 988	9 554
Crude nonmetallic minerals, n.e.s.	449	–	336	785	449	–	336	785
Total nonmetals	2 393 124	5 038 714	2 292 629	9 724 467	2 774 885	4 628 956	2 320 627	9 724 468
Mineral fuels								
Coal and peat for fuel	81 358	2 344 137	56 873	2 482 368	81 358	2 344 137	56 873	2 482 368
Petroleum, crude	310 042	–	–	310 042	310 042	–	–	310 042
Total mineral fuels	391 400	2 344 137	56 873	2 792 410	391 400	2 344 137	56 873	2 792 410
Total crude minerals	11 109 955	7 493 406	2 365 817	20 969 178	6 720 198	11 855 166	2 393 815	20 969 179
Total all commodities	19 966 894	24 396 906	23 208 619	67 572 419	27 536 726	16 817 718	23 217 975	67 572 419
Crude minerals as a percent of all commodities	55.6	30.7	10.2	31.0	24.4	70.5	10.3	31.0

p Preliminary; – Nil; n.e.s. Not elsewhere specified

Note: Totals may not add due to rounding

TABLE 73. CANADA, FABRICATED MINERALS LOADED AND UNLOADED IN COASTWISE SHIPPING, 1987P

	Loaded				Unloaded			
	Atlantic	Great Lakes	Pacific	Total	Atlantic	Great Lakes	Pacific	Total
				(tonnes)				
Metallic mineral products								
Ferrous mineral products								
Structual shapes, iron and steel	359	168 906	25 005	194 270	359	168 906	25 005	194 270
Plates and sheets, steel	352	31 809	408	32 569	351	31 809	408	32 568
Primary iron, steel	21 288	–	–	21 288	–	21 288	–	21 288
Rails and railway track material	2 694	1 683	–	4 377	2 694	1 683	–	4 377
Pipes and tubes, iron and steel	759	1 319	–	2 078	759	1 319	–	2 078
Castings and forgings, steel	14	–	1 633	1 647	14	–	1 633	1 647
Wire, iron and steel	575	–	–	575	575	–	–	575
Bars and rods, steel	389	–	–	389	389	–	–	389
Aluminum and aluminum products	114 932	–	–	114 932	114 932	–	–	114 932
Total metallic mineral products	141 362	203 717	27 046	372 125	120 073	225 005	27 046	372 124
Nonmetallic mineral products								
Cement	27 844	716 903	84 268	829 015	27 844	716 903	84 268	829 015
Sulphuric acid	3 440	–	21 079	24 519	3 440	–	21 079	24 519
Cement basic products	410	12 784	10 302	23 496	410	12 784	10 302	23 496
Fertilizers and fertilizer material, n.e.s.	15 029	–	52	15 081	15 029	–	52	15 081
Other nonmetallic mineral products	6 477	–	–	6 477	6 477	–	–	6 477
Bricks, tiles and pipes, clay	1 228	–	–	1 228	1 228	–	–	1 228
Glass basic products	349	–	454	803	349	–	454	803
Asbestos basic products	–	–	–	–	–	–	–	–
Total nonmetals	54 777	729 687	116 155	900 619	54 777	729 687	116 155	900 619
Mineral fuel products								
Fuel oil	4 097 788	839 194	1 153 104	6 090 086	4 178 579	758 512	1 152 995	6 090 086
Gasoline	2 446 781	378 206	576 362	3 401 349	2 464 231	360 764	576 354	3 401 349
Asphalts and road oils	163 266	18 935	–	182 201	81 803	100 398	–	182 201
Petroleum coke	–	113 609	–	113 609	113 609	–	–	113 609
Lubricating oils and greases	29 467	–	426	29 893	893	28 574	426	29 893
Other petroleum and coal products	25 674	2 052	–	27 726	12 703	15 023	–	27 726
Total mineral fuel products	6 762 976	1 351 996	1 729 892	9 844 864	6 851 818	1 263 271	1 729 775	9 844 864
Total fabricated mineral products	6 959 115	2 285 400	1 873 093	11 117 608	7 026 668	2 217 963	1 872 976	11 117 607
Total all commodities	19 966 894	24 396 906	23 308 619	67 572 419	27 536 726	16 817 718	23 217 975	67 572 419
Fabricated mineral products as a percent of all commodities	34.9	9.4	8.1	16.5	25.5	13.2	8.1	16.5

P Preliminary; – Nil; n.e.s. Not elsewhere specified.
Note: Totals may not add due to rounding.

TABLE 74. CANADA, CRUDE AND FABRICATED MINERALS LOADED AT CANADIAN PORTS IN COASTWISE SHIPPING, 1957-87

	Total All Commodities	Total Crude Minerals	Total Fabricated Minerals	Crude and Fabricated Minerals as Percent of All Products
	(kilotonnes)			
1957	34 354	8 696	7 832	48.1
1958	34 808	7 673	7 258	42.9
1959	36 494	9 984	7 819	48.8
1960	37 058	8 786	8 229	45.9
1961	41 861	9 527	8 857	43.9
1962	39 763	8 361	9 768	45.6
1963	40 328	7 998	9 942	44.5
1964	47 171	8 522	11 194	41.8
1965	48 200	9 183	11 766	43.5
1966	55 122	10 155	12 653	41.4
1967	49 799	11 509	12 207	47.6
1968	50 921	13 698	13 245	52.9
1969	51 890	12 746	14 181	51.9
1970	57 301	14 415	14 818	51.0
1971	55 128	14 783	15 374	54.7
1972	55 326	14 197	15 290	53.3
1973	55 314	16 573	15 615	58.2
1974	53 633	11 723	16 575	52.8
1975	54 373	15 687	17 510	61.1
1976	53 882	15 924	16 208	59.6
1977	58 309	18 131	17 435	61.0
1978	60 668	18 318	16 619	57.6
1979	79 950	22 130	17 486	49.6^r
1980	82 761	22 947	17 134	48.4
1981	71 271	17 849	16 669	48.4
1982	65 881	16 473	13 214	45.1
1983	67 598	21 248	12 025	49.2
1984	68 698	22 798	11 909	50.5
1985	61 717	19 867	10 291	48.9
1986	60 506	19 901	10 264	49.9
1987^p	67 572	20 969	11 118	47.5

^p Preliminary; ^r Revised

TABLE 75. CANADA, CRUDE MINERALS LOADED AND UNLOADED AT CANADIAN PORTS IN INTERNATIONAL SHIPPING TRADE, 1985-87

	1985		1986		1987^P	
	Loaded	Unloaded	Loaded	Unloaded	Loaded	Unloaded
				(tonnes)		
Metallic minerals						
Iron ore and concentrates	32 669 302	6 457 303	30 488 690	6 177 384	31 002 238	6 716 664
Copper ores and concentrates	1 179 258	224 479	1 359 875	92 763	1 601 356	155 112
Other nonferrous ores, concentrates and metal scrap, n.e.s.	108 701	67 347	1 391 039	346 100	1 342 230	252 384
Zinc ore and concentrates	655 418	160	645 143	403	994 894	629
Lead ore and concentrates	110 289	1 916	85 068	11 446	132 778	2 158
Alumina, bauxite ore	45 877	3 320 373	27 216	3 832 453	27 726	3 599 494
Titanium ore	1 032 233	3 782	(2)	(2)	(2)	(2)
Manganese ore	2 522	182 024	(2)	(2)	(2)	(2)
Nickel ore and concentrates	113 252	6 053	(1)	(1)	(1)	(1)
Total metals	35 916 852	10 263 527	33 997 301	10 463 549	35 101 222	10 726 441
Nonmetallic minerals						
Potash	4 759 062	79 292	5 755 702	59 934	6 426 820	283 583
Sulphur	5 371 105	-	5 773 129	42 001	5 920 979	-
Gypsum	5 806 971	77 902	5 781 273	177 148	5 433 907	189 915
Salt	2 053 809	1 253 350	2 222 807	1 227 792	2 067 309	906 523
Crude nonmetallic minerals, n.e.s.	111 735	24 213	1 248 437	1 411 552	1 915 122	1 317 368
Limestone	1 090 691	861 734	1 114 655	1 232 261	1 421 705	1 188 278
Clay materials, n.e.s.	1 236	1 541	716 438	345 832	571 612	249 559
Asbestos	506 633	727	491 951	1 241	505 591	1 845
Sand and gravel	249 850	1 489 944	295 493	1 321 022	408 707	1 395 557
Phosphate rock	2 200	1 557 629	25 590	1 602 018	3 328	1 661 378
Bentonite	165	176 349	(4)	(4)	(4)	(4)
China clay	54	15 379	(4)	(4)	(4)	(4)
Dolomite	377 041	17 674	(3)	(3)	(3)	(3)
Stone, crude, n.e.s.	95 879	91 446	(3)	(3)	(3)	(3)
Stone, crushed	875 543	991 178	(3)	(3)	(3)	(3)
Fluorspar	-	114 081	(3)	(3)	(3)	(3)
Barite	-	8 012	(3)	(3)	(3)	(3)
Total nonmetals	21 301 974	6 760 451	23 425 475	7 420 801	24 675 080	7 194 006
Mineral fuels						
Coal, bituminous	25 964 493	15 168 031	25 986 381	13 589 832	25 324 002	14 334 318
Petroleum, crude	694 576	9 693 288	1 306 998	12 414 057	980 908	14 810 357
Fuels, n.e.s.	343	2 565	3 401	37	3 734	-
Total fuels	26 659 412	24 863 884	27 296 780	26 003 926	26 308 644	29 144 675
Total crude minerals	83 878 238	41 887 862	84 719 556	43 888 276	86 084 946	47 065 122
Total all commodities	143 420 769	60 668 828	144 560 692	62 011 827	158 993 861	68 025 360
Crude minerals as a percent of all commodities	58.5	69.0	58.6	70.8	54.1	69.2

(1) Included with "Copper ores and concentrates". (2) Included with "Other nonferrous ores, concentrates and metal scrap, n.e.s." (3) Included with "Crude nonmetallic minerals, n.e.s." (4) Included with "Clay materials, n.e.s."

- Nil, n.e.s. Not elsewhere specified, ^{P} Preliminary

TABLE 76. CANADA, FABRICATED MINERAL PRODUCTS LOADED AND UNLOADED AT CANADIAN PORTS IN INTERNATIONAL SHIPPING TRADE, 1985-87

	1985		1986		1987P	
	Loaded	Unloaded	Loaded	Unloaded	Loaded	Unloaded
			(tonnes)			
Metallic products						
Iron and steel, other			1 024 616	1 833 389	1 238 605	2 373 878
bars and rods	45 606	291 397	(1)	(1)	(1)	(1)
castings and forgings	43 478	129 390	(1)	(1)	(1)	(1)
pipes and tubes	28 105	316 062	(1)	(1)	(1)	(1)
plates and sheets	285 156	543 381	(1)	(1)	(1)	(1)
rails and track material	29 946	62 771	(1)	(1)	(1)	(1)
structural shapes	9 267	132 351	(1)	(1)	(1)	(1)
wire and rope	14 141	176 398	(1)	(1)	(1)	(1)
Nonferrous metals, n.e.s.	8 193	32 995	716 950	171 168	536 826	243 882
Copper and alloys	176 556	45 850	(2)	(2)	(2)	(2)
Aluminum	446 744	98 430	(2)	(2)	(2)	(2)
Zinc and alloys	124 582	2 692	(2)	(2)	(2)	(2)
Ferroalloys	45 026	39 117	(2)	(2)	(2)	(2)
Nickel and alloys	45 156	33 752	(2)	(2)	(2)	(2)
Lead and alloys	21 844	801	(2)	(2)	(2)	(2)
Iron, pig	425 065	109 793	(1)	(1)	(1)	(1)
Iron and steel, primary	561 992	2 339	(1)	(1)	(1)	(1)
Total metals	2 310 857	2 017 519	1 741 566	2 004 557	1 775 431	2 617 760
Nonmetallic minerals						
Cement	1 051 549	69 216	1 849 287	410 446	1 875 476	515 100
Nonmetallic mineral basic products	26 383	365 818	130 378	353 237	289 902	389 752
Building blocks, n.e.s.	17 471	186 522	(4)	(4)	(4)	(4)
Fertilizers, n.e.s.	224 809	200 035	(4)	(4)	(4)	(4)
Asbestos basic products	1 972	630	(4)	(4)	(4)	(4)
Sulphuric acid	188 554	669 358	(4)	(4)	(4)	(4)
Glass basic products	8 698	46 786	(4)	(4)	(4)	(4)
Cement basic products	534 736	81 305	(3)	(3)	(3)	(3)
Total nonmetals	2 054 172	1 619 670	1 979 665	763 683	2 165 378	904 852
Mineral fuel products						
Fuel oil	2 876 948	2 887 106	2 848 642	3 365 556	3 512 047	4 104 047
Gasoline	1 551 714	793 972	1 401 743	689 495	1 489 372	1 108 892
Coke	1 202 386	1 169 141	199 641	1 225 264	1 180 208	1 231 270
Petroleum and coal products, n.e.s.	790 650	154 065	131 530	310 045	365 073	783 366
Asphalts, road oils	12 777	58 778	(5)	(5)	(5)	(5)
Lubricating oils and greases	8 592	22 806	(5)	(5)	(5)	(5)
Coal tar, pitch	5 978	77 134	(5)	(5)	(5)	(5)
Total fuels	6 449 045	5 163 002	4 581 556	5 590 360	6 546 700	7 227 575
Total fabricated mineral products	10 814 074	8 800 191	8 302 787	8 358 600	10 487 509	10 750 187
Total all commodities	143 420 769	60 668 828	144 560 692	62 011 827	158 993 861	68 025 360
Fabricated mineral products as a percent of all commodities	7.5	14.5	5.7	13.5	6.6	15.8

(1) Included with "Iron and steel, other". (2) Included with "Nonferrous metals, n.e.s." (3) Included with "Cement". (4) Included with "Nonmetallic mineral basic products". (5) Included with "Petroleum and coal products, n.e.s."

P Preliminary; n.e.s. Not elsewhere specified.

TABLE 77. CANADA, CRUDE AND FABRICATED MINERALS LOADED AT CANADIAN PORTS IN INTERNATIONAL SHIPPING TRADE, 1957-87

	Total All Commodities	Total Crude Minerals	Total Fabricated Minerals	Crude and Fabricated Minerals as Percent of All Products
	(kilotonnes)			
1957	44 539	24 210	2 588	60.2
1958	35 559	16 602	1 642	49.9
1959	45 872	25 789	1 619	59.9
1960	45 872	24 671	2 039	58.2
1961	48 771	23 241	2 133	52.0
1962	54 676	30 446	2 296	59.9
1963	62 031	32 214	2 503	56.0
1964	75 760	42 087	2 602	59.0
1965	74 521	41 338	2 746	59.2
1966	76 192	41 374	3 350	58.7
1967	72 598	42 704	3 701	63.9
1968	78 663	48 680	2 960	65.6
1969	70 432	42 442	3 456	65.1
1970	95 807	55 849	4 965	68.5
1971	95 887	53 245	5 022	60.7
1972	98 988	51 912	9 091	61.6
1973	112 434	64 195	10 103	66.1
1974	106 110	64 093	9 041	68.9
1975	102 444	61 970	7 495	67.8
1976	114 815	71 527	6 108	67.6
1977	119 770	70 257	5 979	63.7
1978	116 522	62 291	7 556	59.9
1979	134 639	79 685	8 901	65.8
1980	138 161	67 898	11 770	57.7
1981	145 445	83 007	9 022	63.3
1982	125 282	65 594	7 115	58.1
1983	129 490	67 152	6 197	56.7
1984	145 322	82 752	7 986	62.4
1985	143 421	83 878	10 814	66.0
1986	144 561	84 720	8 303	64.3
1987[p]	158 994	86 085	10 488	60.7

[p] Preliminary

TABLE 78. CANADA, FINANCIAL STATISTICS OF CORPORATIONS IN THE MINING INDUSTRY[1] BY DEGREE OF NON-RESIDENT OWNERSHIP, 1985

	Corporations[2]		Assets[3]		Equity[4]		Sales[5]		Profits[6]		Taxable Income[7]	
	(number)	(%)	($ million)	(%)	($ million)	(%)	($ million)	(%)	($ million)	(%)	($ million)	(%)
Metal mines												
Reporting corporations												
Canadian	195	86.7	21 829	82.3	10 478	84.6	7 468	74.0	95	92.2	247	66.4
Foreign	30	13.3	4 702	17.7	1 906	15.4	2 621	26.0	8	7.8	125	33.6
Total	225	100.0	26 531	100.0	12 384	100.0	10 089	100.0	103	100.0	372	100.0
Mineral fuels												
Reporting corporations												
Canadian	2 242	91.4	51 524	62.3	19 798	57.1	13 526	42.0	3 056	32.4	1 328	20.3
Foreign	211	8.6	31 235	37.7	14 865	42.9	18 655	58.0	6 362	67.6	5 209	79.7
Total	2 453	100.0	82 759	100.0	34 663	100.0	32 181	100.0	9 418	100.0	6 537	100.0
Other mining (including mining services)												
Reporting corporations												
Canadian	4 935	96.4	9 067	74.8	4 074	76.5	4 120	68.6	–84	90.3	234	48.1
Foreign	184	3.6	3 051	25.2	1 249	23.5	1 886	31.4	–9	9.7	252	51.9
Total	5 119	100.0	12 118	100.0	5 323	100.0	6 006	100.0	–93	100.0	486	100.0
Total mining												
Reporting corporations												
Canadian	7 372	94.5	82 420	67.9	34 350	65.6	25 114	52.0	3 067	32.5	1 809	24.5
Foreign	425	5.5	38 988	32.1	18 020	34.4	23 162	48.0	6 361	67.5	5 586	75.5
Total	7 797	100.0	121 408	100.0	52 370	100.0	48 276	100.0	9 428	100.0	7 395	100.0

[1] Cement, lime and clay products (domestic clay) are included in mineral manufacturing. [2] Corporations reporting under the Corporations and Labour Unions Returns Act. A corporation is considered to be foreign controlled if 50 percent or more of its voting rights are known to be held outside Canada, and/or by one or more Canadian corporations which are, in turn, foreign controlled. Each corporation is classified according to the percentage of its voting rights which are owned by non-residents, either directly or through other Canadian corporations, and the whole of the corporation is assigned to this particular degree of foreign ownership. [3] Included are cash, marketable securities, accounts receivable, inventories, fixed assets, investments in affiliated corporations and other assets. The amounts tabulated are those shown on the balance sheets of corporations after deducting allowances for doubtful accounts, amortization, depletion and depreciation. [4] Equity represents the shareholders' interest in the net assets of the corporation and includes the total amount of all issued and paid-up share capital, earnings retained in the business and other surplus accounts such as contributed and capital surplus. [5] For nonfinancial corporations, sales are gross revenues from nonfinancial operations. For financial corporations, sales include income from financial as well as nonfinancial sources. [6] The net earnings from operations, investment income and net capital gains. Profits are tabulated after deducting allowances for amortization, depletion and depreciation, but before income tax provisions or declaration of dividends. [7] Taxable income figures are as reported by corporations prior to assessment by the Department of National Revenue. They include earnings in the reference year after the deduction of applicable losses of other years.
Note: Totals may not add due to rounding.

TABLE 79. CANADA, FINANCIAL STATISTICS OF CORPORATIONS IN THE MINERAL MANUFACTURING INDUSTRIES[1] BY DEGREE OF NON-RESIDENT OWNERSHIP, 1985

	Corporations[2]		Assets[3]		Equity[4]		Sales[5]		Profits[6]		Taxable Income[7]	
	(number)	(%)	($ million)	(%)	($ million)	(%)	($ million)	(%)	($ million)	(%)	($ million)	(%)
Primary metal products												
Reporting corporations												
Canadian	376	90.0	14 105	79.8	6 107	84.1	11 840	83.2	89	54.3	363	79.8
Foreign	42	10.0	3 568	20.2	1 158	15.9	2 396	16.8	75	45.7	92	20.2
Total	418	100.0	17 673	100.0	7 265	100.0	14 236	100.0	164	100.0	455	100.0
Nonmetallic mineral products												
Reporting corporations												
Canadian	1 516	95.5	2 376	29.2	961	22.8	3 018	45.1	214	28.6	187	39.0
Foreign	71	4.5	5 762	70.8	3 251	77.2	3 678	54.9	535	71.4	292	61.0
Total	1 587	100.0	8 138	100.0	4 212	100.0	6 696	100.0	749	100.0	479	100.0
Petroleum and coal products												
Reporting corporations												
Canadian	109	83.2	22 671	57.9	10 101	51.2	15 205	42.6	1 329	53.3	534	64.0
Foreign	22	16.8	16 495	42.1	9 619	48.8	20 497	57.4	1 166	46.7	300	36.0
Total	131	100.0	39 166	100.0	19 720	100.0	35 702	100.0	2 495	100.0	834	100.0
Total mineral manufacturing industries												
Reporting corporations												
Canadian	2 001	93.7	39 152	60.3	17 169	55.0	30 063	53.1	1 632	47.9	1 084	61.3
Foreign	135	6.3	25 825	39.7	14 028	45.0	26 571	46.9	1 776	52.1	684	38.7
Total	2 136	100.0	64 977	100.0	31 197	100.0	56 634	100.0	3 408	100.0	1 768	100.0

[1] Includes cement, lime and clay products (domestic clay). [2] Corporations reporting under the Corporations and Labour Unions Returns Act. A corporation is considered to be foreign controlled if 50 percent or more of its voting rights are known to be held outside Canada, and/or by one or more Canadian corporations which are, in turn, foreign controlled. Each corporation is classified according to the percentage of its voting rights which are owned by non-residents, either directly or through other Canadian corporations, and the whole of the corporation is assigned to this particular degree of foreign ownership. [3] Included are cash, marketable securities, accounts receivable, inventories, fixed assets, investments in affiliated corporations and other assets. The amounts tabulated are those shown on the balance sheets of corporations after deducting allowances for doubtful accounts, amortization, depletion and depreciation. [4] Equity represents the shareholders' interest in the net assets of the corporation and includes the total amount of all issued and paid-up share capital, earnings retained in the business and other surplus accounts such as contributed and capital surplus. [5] For nonfinancial corporations, sales are gross revenues from nonfinancial operations. For financial corporations, sales include income from financial as well as nonfinancial sources. [6] The net earnings from operations, investment income and net capital gains. Profits are tabulated after deducting allowances for amortization, depletion and depreciation, but before income tax provisions or declaration of dividends. [7] Taxable income figures are as reported by corporations prior to assessment by the Department of National Revenue. They include earnings in the reference year after the deduction of applicable losses of other years.

Note: Totals may not add due to rounding.

TABLE 80. CANADA, FINANCIAL STATISTICS OF CORPORATIONS IN NONFINANCIAL INDUSTRIES BY MAJOR INDUSTRY GROUP AND BY CONTROL, 1984 AND 1985

	Agriculture, Forestry, Fishing and Trapping		Mines, Quarries and Oil Wells		Manufacturing		Construction		Transportation, Communication and Other Utilities		Trade		Services		Total	
	1984	1985^p	1984	1985^p	1984	1985^p	1984	1985^p	1984	1985^p	1984	1985^p	1984	1985^p	1984	1985^p
								(number)								
Corporations[1]																
Canadian Control	22 520	22 949	7 139	7 372	39 781	40 001	57 614	59 142	24 023	24 623	130 690	134 007	116 466	120 323	398 233	408 417
Foreign Control	92	81	483	425	1 990	1 800	156	144	279	253	1 812	1 682	697	642	5 509	5 027
Total	22 612	23 030	7 622	7 797	41 771	41 801	57 770	59 286	24 302	24 876	132 502	135 689	117 163	120 965	403 742	413 444
								($ million)								
Assets[2]																
Canadian Control	11 891	12 224	75 987	82 421	108 681	126 003	19 246	20 338	163 038	175 011	84 140	91 235	40 461	42 645	503 444	549 877
Foreign Control	414	440	38 923	38 988	86 703	90 271	1 929	1 877	5 790	6 029	19 924	21 797	7 483	8 148	161 166	167 550
Total	12 305	12 664	114 910	121 409	195 384	216 274	21 175	22 215	168 828	181 040	104 064	113 032	47 944	50 793	664 610	717 427
Equity[3]																
Canadian Control	3 963	4 306	31 363	34 350	40 422	49 457	4 298	4 888	44 187	47 541	24 253	26 405	9 567	10 497	158 053	177 444
Foreign Control	171	171	18 013	18 020	44 171	46 530	768	660	2 071	2 110	6 949	7 512	3 038	3 492	75 181	78 495
Total	4 134	4 477	49 376	52 370	84 593	95 987	5 066	5 548	46 258	49 651	31 202	33 917	12 605	13 989	233 234	255 939
Sales[4]																
Canadian Control	9 244	9 569	22 936	25 114	133 405	144 186	35 417	38 417	75 092	79 219	211 340	226 872	44 441	48 219	531 875	571 596
Foreign Control	327	285	22 964	23 162	135 503	139 624	2 726	2 831	4 453	4 474	50 434	54 494	8 577	8 807	224 984	233 677
Total	9 571	9 854	45 900	48 276	268 908	283 810	38 143	41 248	79 545	83 693	261 774	281 366	53 018	57 026	756 859	805 273
Profits[5]																
Canadian Control	456	476	2 639	3 066	5 835	6 283	947	1 286	6 190	5 199	7 082	7 148	2 996	3 313	26 145	26 771
Foreign Control	47	54	6 983	6 361	9 932	8 813	144	72	527	559	1 190	1 442	1 073	1 047	19 896	18 348
Total	503	530	9 622	9 427	15 767	15 096	1 091	1 358	6 717	5 758	8 272	8 590	4 069	4 360	46 041	45 119

[1] Corporations reporting under the Corporations and Labour Unions Returns Act. A corporation is considered to be foreign controlled if 50 percent or more of its voting rights are known to be held outside Canada, and/or by one or more Canadian corporations which are, in turn, foreign controlled. Each corporation is classified according to the percentage of its voting rights which are owned by non-residents, either directly or through other Canadian corporations, and the whole of the corporation is assigned to this particular degree of foreign ownership. [2] Included are cash, marketable securities, accounts receivable, inventories, fixed assets, investments in affiliated corporations and other assets. The amounts tabulated are those shown on the balance sheets of corporations after deducting allowances for doubtful accounts, amortization, depletion and depreciation. [3] Equity represents the shareholders' interest in the net assets of the corporation and includes the total amount of all issued and paid-up share capital, earnings retained in the business and other surplus accounts such as contributed and capital surplus. [4] For nonfinancial corporations, sales are gross revenues from nonfinancial operations. For financial corporations, sales include income from financial as well as nonfinancial sources. [5] The net earnings from operations, investment income and net capital gains. Profits are tabulated after deducting allowances for amortization, depletion and depreciation, but before income tax provisions or declaration of dividends.

^{p} Preliminary.

Note: Totals may not add due to rounding.

TABLE 81. CANADA, CAPITAL AND REPAIR EXPENDITURES BY SELECTED INDUSTRIAL SECTORS, 1986-88

		Capital Expenditures			Repair Expenditures			Capital and Repair Expenditures		
		Construction	Machinery and Equipment	Total	Construction	Machinery and Equipment	Total	Construction	Machinery and Equipment	Total
						($ million)				
Agriculture	1986	781.3	1 980.0	2 761.3	241.6	1 217.3	1 458.9	1 022.9	3 197.3	4 220.2
	1987^p	739.1	1 875.0	2 614.1	254.1	1 271.4	1 525.5	993.2	3 146.4	4 139.6
	1988^i	766.6^r	1 906.6^r	2 673.2^r	267.8	1 360.1	1 627.9	1 034.4^r	3 266.7^r	4 301.1^r
Construction	1986	289.0	1 155.0	1 444.0	59.1	924.2	983.3	348.1	2 079.2	2 427.3
	1987^p	315.0	1 262.0	1 577.0	60.4	915.6	976.0	375.4	2 177.6	2 553.0
	1988^i	349.8^r	1 484.2^r	1 834.0^r	64.4	1 069.8	1 134.2	414.2^r	2 554.0^r	2 968.2^r
Forestry	1986	108.7	121.8	230.5	78.8	219.1	297.9	187.5	340.9	528.4
	1987^p	111.1	118.9	230.0	75.2	225.4	300.6	186.3	344.3	530.6
	1988^i	143.0^r	159.8^r	302.8^r	76.1	230.3	306.4	219.1^r	390.1^r	609.2^r
Housing	1986	25 764.3	–	25 764.3	3 121.0	–	3 121.0	28 885.3	–	28 885.3
	1987^p	32 803.3	–	32 803.3	3 200.0	–	3 200.0	36 003.3	–	36 003.3
	1988^i	33 324.8^r	–	33 324.8^r	3 300.0	–	3 300.0	36 624.8^r	–	36 624.8^r
Manufacturing	1986	2 525.5	11 723.8	14 249.3	868.9	5 651.4	6 520.3	3 394.4	17 375.2	20 769.6
	1987^p	2 703.2	12 250.3	14 953.5	935.6	5 837.7	6 773.3	3 638.8	18 088.0	21 726.8
	1988^i	3 229.1^r	15 933.9^r	19 163.0^r	973.2	6 128.3	7 101.5	4 202.3^r	22 062.2^r	26 264.5^r
Mining[1]	1986	6 624.5	1 072.4	7 696.9	447.3	2 082.2	2 529.5	7 071.8	3 154.6	10 226.4
	1987^p	5 621.9	1 080.6	6 702.5	432.9	2 110.5	2 543.4	6 054.8	3 191.1	9 245.9
	1988^i	7 178.4^r	1 549.0^r	8 727.4^r	492.4	2 223.2	2 715.6	7 670.8^r	3 772.2^r	11 443.0^r
Trade	1986	780.4	1 853.1	2 633.5	256.5	407.0	663.5	1 036.9	2 260.1	3 297.0
	1987^p	813.7	1 929.3	2 743.0	239.0	370.1	609.1	1 052.7	2 299.4	3 352.1
	1988^i	934.7^r	2 147.8^r	3 082.5^r	249.6	378.6	628.2	1 184.3^r	2 526.4^r	3 710.7^r
Utilities	1986	6 412.0	6 906.2	13 318.2	2 046.6	5 158.2	7 204.8	8 458.6	12 064.4	20 523.0
	1987^p	6 930.0	7 676.9	14 606.9	1 978.6	5 311.6	7 290.2	8 908.6	12 988.5	21 897.1
	1988^i	8 798.4^r	9 732.6^r	18 531.0^r	2 082.4	5 552.2	7 634.6	10 880.8^r	15 284.8^r	26 165.6^r
Other[2]	1986	17 830.9	11 156.7	28 987.6	3 462.8	1 683.2	5 146.0	21 293.7	12 839.9	34 133.6
	1987^p	19 585.8	12 712.8	32 298.6	4 056.6	1 818.1	5 874.7	23 642.4	14 530.9	38 173.3
	1988^i	21 336.0^r	13 977.6^r	35 313.6^r	4 264.2	1 906.7	6 170.9	25 600.2^r	15 884.3^r	41 484.5^r
Total	1986	61 116.6	35 969.0	97 085.6	10 582.6	17 342.6	27 925.2	71 699.2	53 311.6	125 010.8
	1987^p	69 623.1	38 905.8	108 528.9	11 232.4	17 860.4	29 092.8	80 855.5	56 766.2	137 621.7
	1988^i	76 060.8^r	46 891.5^r	122 952.3^r	11 770.1	18 849.2	30 619.3	87 830.9^r	65 740.7^r	153 571.6^r
Mining as a percentage of total	1986	10.8	3.0	7.9	4.2	12.0	9.1	9.9	5.9	8.2
	1987^p	8.1	2.8	6.2	3.9	11.8	8.7	7.5	5.6	6.7
	1988^i	9.4^r	3.3^r	7.1^r	4.2	11.8	8.9	8.7^r	5.7^r	7.5

[1] Includes mines, quarries and oil wells. [2] Includes finance, real estate, insurance, commercial services, institutions and government departments.

^{p} Preliminary; ^{r} Revised; ^{i} Intentions; – Nil.

TABLE 82. CANADA, CAPITAL AND REPAIR EXPENDITURES IN MINING[1] BY GEOGRAPHICAL REGION, 1986-88

		Capital Expenditures			Repair Expenditures			Capital and Repair Expenditures		
		Construction	Machinery and Equipment	Total	Construction	Machinery and Equipment	Total	Construction	Machinery and Equipment	Total
		($ million)								
Atlantic Region	1986	950.8	108.8	1 059.6	18.0	190.7	208.7	968.8	299.5	1 268.3
	1987[p]	506.6	104.6	611.2	19.4	204.6	224.0	526.0	309.2	835.2
	1988[i]	365.5[r]	112.4[r]	477.9[r]	19.4	212.9	232.3	384.9[r]	325.3[r]	710.2[r]
Quebec	1986	261.5	60.8	322.3	29.1	193.1	222.2	290.6	253.9	544.5
	1987[p]	310.5	82.9	393.4	30.1	190.4	220.5	340.6	273.3	613.9
	1988[i]	341.3[r]	106.9[r]	448.2[r]	29.9	192.5	222.4	371.2[r]	299.4[r]	670.6[r]
Ontario	1986	460.0	154.9	614.9	42.2	326.2	368.4	502.2	481.1	983.3
	1987[p]	498.2	200.5	698.7	40.6	359.1	399.7	538.8	559.6	1 098.4
	1988[i]	681.4[r]	334.9[r]	1 016.3[r]	47.9	370.3	418.2	729.3[r]	705.2[r]	1 434.5[r]
Prairie Region	1986	3 897.4	646.6	4 544.0	301.8	918.7	1 220.5	4 199.2	1 565.3	5 764.5
	1987[p]	3 536.5	570.2	4 106.7	303.2	882.8	1 186.0	3 839.7	1 453.0	5 292.7
	1988[i]	4 822.2[r]	828.2[r]	5 650.4[r]	338.4	966.7	1 305.1	5 160.6[r]	1 794.9[r]	6 955.5[r]
British Columbia	1986	493.5	94.0	587.5	45.9	389.1	435.0	539.4	483.1	1 022.5
	1987[p]	540.2	97.1	637.3	36.6	400.0	436.6	576.8	497.1	1 073.9
	1988[i]	734.9[r]	119.4[r]	854.3[r]	41.7	411.7	453.4	776.6[r]	531.1[r]	1 307.7[r]
Yukon and	1986	561.3	7.3	568.6	10.3	64.4	74.7	571.6	71.7	643.3
Northwest	1987[p]	229.9	25.3	255.2	3.0	73.6	76.6	232.9	98.9	331.8
Territories	1988[i]	233.1[r]	47.2[r]	280.3[r]	15.1	69.1	84.2	248.2[r]	116.3[r]	364.5[r]
Canada, total	1986	6 624.5	1 072.4	7 696.9	447.3	2 082.2	2 529.5	7 071.8	3 154.6	10 226.4
	1987[p]	5 621.9	1 080.6	6 702.5	432.9	2 110.5	2 543.4	6 054.8	3 191.1	9 245.9
	1988[i]	7 178.4[r]	1 549.0[r]	8 727.4[r]	492.4	2 223.2	2 715.6	7 670.8[r]	3 772.2[r]	11 443.0[r]

[1] Includes mines, quarries and oil wells.
[p] Preliminary; [r] Revised; [i] Intentions.
Note: Totals may not add due to rounding.

TABLE 83. CANADA, CAPITAL AND REPAIR EXPENDITURES IN MINING[1] AND MINERAL MANUFACTURING INDUSTRIES, 1986-88

	1986			1987[p]			1988[i]		
	Capital	Repair	Total	Capital	Repair	Total	Capital	Repair	Total
					($ million)				
Mining Industry									
Metal mines									
Copper-gold-silver	223.4	225.1	448.5	229.8	259.5	489.3	285.1[r]	257.3	542.4[r]
Gold	516.0	126.0	642.0	737.1	136.7	873.8	1 026.5[r]	172.5	1 199.0[r]
Iron	118.3	202.2	320.5	116.7	178.7	295.4	126.9[r]	180.5	307.4[r]
Silver-lead-zinc	62.7	84.7	147.4	118.3	108.4	226.7	123.0[r]	119.0	242.0[r]
Other metal mines	378.7	272.9	651.6	333.2	286.7	619.9	501.6[r]	289.9	791.5[r]
Total metal mines	1 299.1	910.9	2 210.0	1 535.1	970.0	2 505.1	2 063.1[r]	1 019.2	3 082.3[r]
Nonmetal mines									
Asbestos	43.6	39.2	82.8	51.2	46.9	98.1	15.1[r]	54.9	70.0[r]
Other nonmetal mines[2]	715.4	557.4	1 272.8	610.0	545.9	1 155.9	639.9[r]	554.2	1 194.1[r]
Total nonmetal mines	759.0	596.6	1 355.6	661.2	592.8	1 254.0	655.0[r]	609.1	1 264.1[r]
Mineral fuels									
Petroleum and gas[3]	5 638.8	1 022.0	6 660.8	4 506.2	980.6	5 486.8	6 009.3[r]	1 087.3	7 096.6[r]
Total mining industries	7 696.9	2 529.5	10 226.4	6 702.5	2 543.4	9 245.9	8 727.4[r]	2 715.6	11 443.0[r]
Mineral Manufacturing									
Primary metal industries									
Aluminum rolling, casting and extruding	48.2	59.3	107.5	46.8	53.4	100.2	89.9[e]	57.2	147.1[e]
Copper and copper alloy, rolling, casting and extruding	8.6	9.7	18.3	13.9	14.5	28.4	8.9[e]	14.2	23.1[e]
Iron and steel mills	843.2	793.5	1 636.7	774.8	828.0	1 602.8	801.9[e]	942.8	1 744.7[e]
Iron foundries	51.4	62.3	113.7	42.3	57.3	99.6	25.6[e]	58.6	84.2[e]
Metal rolling, casting and extruding	28.9	22.6	51.5	25.4	16.8	42.2	21.2[e]	17.5	38.7[e]
Smelting and refining	583.1	403.6	986.7	541.3	467.1	1 008.4	813.7[e]	479.9	1 293.6[e]
Steel pipe and tube mills	170.4	54.9	225.3	59.0	62.4	121.4	56.2[e]	67.5	123.7[e]
Total primary metal industries	1 733.8	1 405.9	3 139.7	1 503.5	1 499.5	3 003.0	1 817.4[r]	1 637.7	3 455.1[r]

Nonmetallic mineral products									
Abrasives	5.3	13.3	18.6	7.0	11.3	18.3	9.0^{e}	11.7	20.7^{e}
Cement	52.2	85.7	137.9	42.0	86.8	128.8	108.7^{e}	94.0	202.7^{e}
Clay products	12.2	6.0	18.2	26.8	8.5	35.3	21.2^{e}	8.0	29.2^{e}
Concrete products	50.0	31.2	81.2	34.5	29.9	64.4	36.2^{e}	29.0	65.2^{e}
Glass and glass products	95.9	30.4	126.3	97.0	27.7	124.7	99.5^{e}	29.2	128.7^{e}
Lime	9.1	8.6	17.7	5.6	5.9	11.5	7.2^{e}	6.6	13.8^{e}
Ready-mix concrete	60.2	65.9	126.1	61.2	60.9	122.1	94.1^{e}	57.7	151.8^{e}
Stone products	2.2	0.4	2.6	7.2	1.5	8.7	2.0^{e}	1.6	3.6^{e}
Other nonmetallic mineral products	44.0	68.9	112.9	44.8	58.5	103.3	113.0^{e}	57.9	170.9^{e}
Total nonmetallic mineral products	331.1	310.4	641.5	326.1	291.0	617.1	490.9^{r}	295.7	786.6^{r}
Petroleum and coal products									
Petroleum refineries	392.8	288.1	680.9	650.8	359.6	1 010.4	747.7^{e}	344.2	1 091.9^{e}
Petroleum and coal products	5.4	15.8	21.2	9.0	15.1	24.1	7.5^{e}	15.1	22.6^{e}
Total petroleum and coal products	398.2	303.9	702.1	659.8	374.7	1 034.5	755.2^{r}	359.3	1 114.5^{r}
Total mineral manufacturing industries	2 463.1	2 020.2	4 483.3	2 489.4	2 165.2	4 654.6	3 063.5^{r}	2 292.7	5 356.2^{r}
Total mining and mineral manufacturing industries	10 160.0	4 549.7	14 709.7	9 191.9	4 708.6	13 900.5	11 790.9^{r}	5 008.3	16 799.2^{r}

[1] Does not include cement, lime and clay products (domestic clay) manufacturing, smelting and refining. [2] Includes coal mines, gypsum, salt, potash and miscellaneous nonmetal mines and quarrying. [3] The total of capital expenditures shown under "petroleum and gas" is equal to the total capital expenditure under the columns entitled "petroleum and natural gas extraction", "natural gas processing plants" and "oil and gas drilling contractors" of Table 86.

^{p} Preliminary; ^{r} Revised; ^{e} Estimated; ^{i} Intentions.

Note: Totals may not add due to rounding.

TABLE 84. CANADA, CAPITAL AND REPAIR EXPENDITURES IN THE MINING INDUSTRY[1], 1982-88

	1982	1983	1984	1985	1986	1987[p]	1988[i]
				($ million)			
Metal Mines							
Capital							
Construction	1 099 4	839 1	942 2	1 053 5	979 7	1 176 0	1 503 7[r]
Machinery	370 6	312 0	372 7	322 4	319 4	359 1	559 4[r]
Total	1 470 0	1 151 1	1 314 9	1 375 9	1 299 1	1 535 1	2 063 1[r]
Repair							
Construction	112 4	93 3	99 6	104 5	99 6	93 0	112 4
Machinery	805 1	728 0	861 1	846 4	811 3	877 0	906 8
Total	917 5	821 3	960 7	950 9	910 9	970 0	1 019 2
Total capital and repair	2 387 5	1 972 4	2 275 6	2 326 8	2 210 0	2 505 1	3 082 3[r]
Nonmetal Mines[2]							
Capital							
Construction	888 6	1 123 3	658 6	573 6	502 4	420 0	351 5[r]
Machinery	563 3	433 9	571 7	350 1	256 6	241 2	303 5[r]
Total	1 451 9	1 557 2	1 230 3	923 7	759 0	661 2	655 0[r]
Repair							
Construction	28 6	25 5	47 2	39 3	31 2	27 4	28 2
Machinery	431 8	401 5	454 8	529 5	565 4	565 4	580 9
Total	460 4	427 0	502 0	568 8	596 6	592 8	609 1
Total capital and repair	1 912 3	1 984 2	1 732 3	1 492 5	1 355 6	1 254 0	1 264 1[r]
Mineral Fuels							
Capital							
Construction	6 019 2	6 034 1	6 643 5	7 645 9	5 142 4	4 025 9	5 323 2[r]
Machinery	1 420 5	880 6	686 7	959 7	496 4	480 3	686 1[r]
Total	7 439 7	6 914 7	7 330 2	8 605 6	5 638 8	4 506 2	6 009 3[r]
Repair							
Construction	484 4	427 4	283 4	374 3	316 5	312 5	351 8
Machinery	698 3	656 7	709 5	761 3	705 5	668 1	735 5
Total	1 182 7	1 084 1	992 9	1 135 6	1 022 0	980 6	1 087 3
Total capital and repair	8 622 4	7 998 8	8 323 1	9 741 2	6 660 8	5 486 8	7 096 6[r]
Total Mining							
Capital							
Construction	8 007 2	7 996 5	8 244 3	9 273 0	6 624 5	5 621 9	7 178 4[r]
Machinery	2 354 4	1 626 5	1 631 1	1 632 2	1 072 4	1 080 6	1 549 0[r]
Total	10 361 6	9 623 0	9 875 4	10 905 2	7 696 9	6 702 5	8 727 4[r]
Repair							
Construction	625 4	546 2	430 2	518 1	447 3	432 9	492 4
Machinery	1 935 2	1 786 2	2 025 4	2 137 2	2 082 2	2 110 5	2 223 2
Total	2 560 6	2 332 4	2 455 6	2 655 3	2 529 5	2 543 4	2 715 6
Total capital and repair	12 922 2	11 955 4	12 331 0	13 560 5	10 226 4	9 245 9	11 443 0[r]

[1] Does not include cement, lime and clay products (domestic clays) manufacturing, smelting and refining [2] Includes coal mines, asbestos, gypsum, salt, potash, miscellaneous nonmetals, quarrying and sand pits
[p] Preliminary; [r] Revised; [i] Intentions
Note: Totals may not add due to rounding

TABLE 85. CANADA, CAPITAL AND REPAIR EXPENDITURES IN THE MINERAL MANUFACTURING INDUSTRIES, 1982-88

	1982	1983	1984	1985	1986	1987^{p}	1988^{i}
				($ million)			
Primary Metal Industries[1]							
Capital							
Construction	278.3	112.5	318.6	593.8	400.2	230.7	321.1^{r}
Machinery	927.5	550.6	712.6	1 019.0	1 333.6	1 272.8	1 496.3^{r}
Total	1 205.8	663.1	1 031.2	1 612.8	1 733.8	1 503.5	1 817.4^{r}
Repair							
Construction	99.2	111.4	119.6	125.2	126.9	152.1	165.3
Machinery	1 021.6	1 053.1	1 215.7	1 231.1	1 279.0	1 347.4	1 472.4
Total	1 120.8	1 164.5	1 335.3	1 356.3	1 405.9	1 499.5	1 637.7
Total capital and repair	2 326.6	1 827.6	2 366.5	2 969.1	3 139.7	3 003.0	3 455.1^{r}
Nonmetallic Mineral Products[2]							
Capital							
Construction	32.0	14.8	26.6	39.2	36.0	54.1	69.7^{r}
Machinery	134.4	125.5	151.0	193.2	295.1	272.0	421.2^{r}
Total	166.4	140.3	177.6	232.4	331.1	326.1	490.9^{r}
Repair							
Construction	20.7	20.7	26.3	21.2	24.7	19.8	19.7
Machinery	211.1	204.1	236.5	270.6	285.7	271.2	276.0
Total	231.8	224.8	262.8	291.8	310.4	291.0	295.7
Total capital and repair	398.2	365.1	440.4	524.2	641.5	617.1	786.6^{r}
Petroleum and Coal Products							
Capital							
Construction	890.8	629.6	321.4	248.3	272.3	437.2	507.4^{r}
Machinery	333.7	211.2	111.0	87.4	125.9	222.6	247.8^{r}
Total	1 224.5	840.8	432.4	335.7	398.2	659.8	755.2^{r}
Repair							
Construction	218.5	196.0	230.3	213.0	212.0	254.6	244.3
Machinery	101.2	68.6	79.3	74.9	91.9	120.1	115.0
Total	319.7	264.6	309.6	287.9	303.9	374.7	359.3
Total capital and repair	1 544.2	1 105.4	742.0	623.6	702.1	1 034.5	1 114.5^{r}
Total Mineral Manufacturing Industries							
Capital							
Construction	1 201.1	756.9	666.6	881.3	708.5	722.0	898.2^{r}
Machinery	1 395.6	887.3	974.6	1 299.6	1 754.6	1 767.4	2 165.3^{r}
Total	2 596.7	1 644.2	1 641.2	2 180.9	2 463.1	2 489.4	3 063.5^{r}
Repair							
Construction	338.4	328.1	376.2	359.4	363.6	426.5	429.3
Machinery	1 333.9	1 325.8	1 531.5	1 576.6	1 656.6	1 738.7	1 863.4
Total	1 672.3	1 653.9	1 907.7	1 936.0	2 020.2	2 165.2	2 292.7
Total capital and repair	4 269.0	3 298.1	3 548.9	4 116.9	4 483.3	4 654.6	5 356.2^{r}

[1] Includes smelting and refining. [2] Includes cement, lime and clay products manufacturing.
^{p} Preliminary; ^{r} Revised; ^{i} Intentions.
Note: Totals may not add due to rounding.

71.90

TABLE 86. CANADA, CAPITAL EXPENDITURES IN THE PETROLEUM, NATURAL GAS AND ALLIED INDUSTRIES[1], 1982-88

	Petroleum and Natural Gas Extraction	Transportation (Pipelines)	Marketing (Chiefly Outlets of Oil Companies)	Natural Gas Distribution	Petroleum and Coal Products Industries	Natural Gas Processing Plants	Oil and Gas Drilling Contractors	Total Capital Expenditures
				($ million)				
1982	6 743.4	1 994.3	320.5	517.6	1 224.5	522.8	173.5	11 496.6
1983	6 563.5	660.5	374.5	516.8	840.8	195.8	155.4	9 307.3
1984	6 946.4	795.4	422.9	604.1	432.4	340.0	43.8	9 585.0
1985	8 187.6	664.2	356.8	603.5	335.7	337.7	80.1	10 565.6
1986	5 401.1	586.9	344.9	573.9	398.2	207.8	29.9	7 542.7
1987^{p}	4 331.7^{r}	528.7^{r}	425.8^{r}	533.9^{r}	659.8	160.9	13.6	6 654.4^{r}
1988^{i}	5 746.2^{r}	915.2^{r}	470.5^{r}	544.9^{r}	755.2^{r}	245.0^{r}	18.1^{r}	8 695.1^{r}

[1] The petroleum and natural gas industries in this table include all companies engaged in whole or in part in oil and gas activities

^{p} Preliminary; ^{r} Revised; ^{i} Intentions.

Note: Totals may not add due to rounding.

TABLE 87. CANADA, TOTAL INTRAMURAL RESEARCH AND DEVELOPMENT EXPENDITURES FOR MINING–RELATED INDUSTRIES IN CURRENT AND CONSTANT (1981) DOLLARS, 1982–88

	1982	1983	1984	1985	1986	1987^{p}	1988^{f}
				($ million)			
Current dollars							
Mining industry	132	92	115	119^{r}	86^{r}	81	91
Mines	48	43	48^{r}	51^{r}	49^{r}	50	58
Oil and gas wells	85	49	67^{r}	69^{r}	37^{r}	31	33
Mineral manufacturing	362	297	358	345	278^{r}	286	293
Ferrous primary metals	23	21	26	27	27^{r}	32	30
Nonferrous primary metals	86	82	95	93^{r}	88^{r}	103	104
Nonmetallic mineral products	9	10	17^{r}	19	16	17	17
Petroleum products	244	184	218	205	147^{r}	134	142
Constant dollars							
Mining industry	122^{r}	81^{r}	97^{r}	98^{r}	68^{r}	62	69
Mines	44^{r}	38^{r}	40^{r}	42^{r}	39^{r}	38	44
Oil and gas wells	78^{r}	43^{r}	57^{r}	56^{r}	30	24	25
Mineral manufacturing	333^{r}	261^{r}	301^{r}	282^{r}	221^{r}	220	221
Ferrous primary metals	21^{r}	19^{r}	22^{r}	22^{r}	21^{r}	25	23
Nonferrous primary metals	79^{r}	72^{r}	80^{r}	76^{r}	70^{r}	79	78
Nonmetallic mineral products	8^{r}	9^{r}	14^{r}	16^{r}	12^{r}	13	13
Petroleum products	225^{r}	161^{r}	185^{r}	168^{r}	118^{r}	103	107

^{p} Preliminary; ^{f} Forecast; ^{r} Revised.

Note: Totals may not add due to rounding.

TABLE 88. CANADA, CURRENT AND CAPITAL INTRAMURAL RESEARCH AND DEVELOPMENT EXPENDITURES FOR MINING-RELATED INDUSTRIES, 1982–88

	1982	1983	1984	1985	1986	1987[p]	1988[f]
				($ million)			
Capital expenditures							
Mining industry	36	21	21	27[r]	8[r]	7	11
Mines	4	5[r]	5[r]	4	5[r]	3	5
Oil and gas wells	33	16[r]	16[r]	23[r]	3[r]	4	6
Mineral manufacturing	81	48	97	82	30[r]	38	32
Ferrous primary metals	1	1	1	3	3	7	4
Nonferrous primary metals	10	5	9	5	7	14	11
Nonmetallic mineral products	1	1	6	6	3	4	4
Petroleum products	69	41	81	68	17	13	13
Current expenditures							
Mining industry	96	71	94	92[r]	78[r]	74	79
Mines	44	38	43[r]	47[r]	44[r]	47	52
Oil and gas wells	52	33	51[r]	46[r]	34[r]	27	27
Mineral manufacturing	281	250	259[r]	260[r]	247[r]	247	262
Ferrous primary metals	22	21	25	23	24[r]	25	26
Nonferrous primary metals	76	77	86	87[r]	80[r]	88	93
Nonmetallic mineral products	8	9	11[r]	13[r]	12[r]	13	13
Petroleum products	175	143	137	137[r]	131[r]	121	130
Total expenditures							
Mining industry	132	92	115	120[r]	86[r]	81	90
Mines	48	43	48[r]	51[r]	49[r]	50	57
Oil and gas wells	85	49	67[r]	69[r]	37[r]	31	33
Mineral manufacturing	362	297	356[r]	344[r]	277[r]	285	294
Ferrous primary metals	23	21	26	26[r]	27[r]	32	30
Nonferrous primary metals	86	82	95	94	87[r]	102	104
Nonmetallic mineral products	9	10	17[r]	19	15[r]	17	17
Petroleum products	244	184	218	205	148[r]	134	143

[p] Preliminary; [f] Forecast; [r] Revised
Note: Totals may not add due to rounding